Course title Group Date

Number of laboratory instruction

Name Surname [1)]

1) Gdańsk University of Technology, Faculty of Chemistry, field of study, year of study, semester of study

Abstract: Describe in several sentences what the experiment was essentially about, which parameters were measured and what was the objective of the study. Report the results with a brief comment.

Keywords: Three to five words that clearly define subject matter in given experiment.

1. Introduction

Describe current situation in your homeland concerning the usage of analysed energy source. Include information about the degree of prevalence, any additional funding provided in your country and occurring drawbacks. Using abbreviations in nomenclature is allowed, however they must be defined as they appear in text for the first time. For all of the data and figures sources should be identified in such a way as it was presented in paragraphs below.

Nowadays, around 90% of Polish market [1] consists of silicon based mono- and polycrystalline first generation modules, while the rest belongs to second generation amorphous silicon ($a - Si$), copper indium selenide (CIS) and copper indium gallium selenide (CIGS). The scheme of the photovoltaic cell structure is presented in figure 1.1.

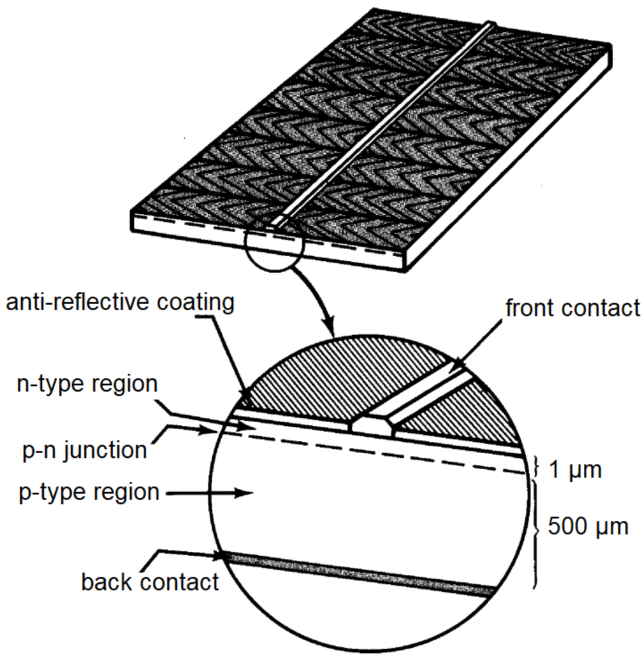

Fig. 1.1. Silicon based photovoltaic cell layout [1]

The primary element of solar cell is p-n junction, as shown in figure 1.2. In the silicon based solar battery electron and hole conductivity are obtained by doping the material with phosphorus and boron respectively [2]. At room temperature it may be assumed that all acceptor dopants n_A in type p semiconductor and donor dopants n_D in type n semiconductor are ionised. Then, there are grounds for applying such an approximation that equates concentration of majority carriers to their dopants. Once p-n junction is formed, there is a high carrier concentration gradient on the border area, which allows for electron and hole diffusion and depletion layer formation. Therefore, space charge of thickness d is created – positive on the n site, because electrons diffuse into p region, and negative on the p site, following the same relation. The resulting potential difference between area p and n is called diffusion voltage, U_d.

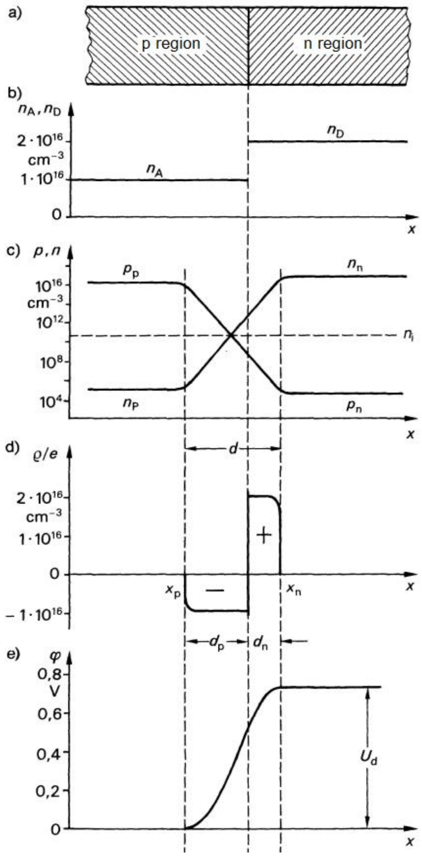

Fig. 1.2. Asymmetric p-n junction in silicon based material: a) połączenie półprzewodnika typu p i n, b) acceptor concentration $n_A = 1 \cdot 10^{16}$cm^{-3} and donor concentration $n_D = 2 \cdot 10^{16}$cm^{-3}, c) free carrier concentration, d) volume charge density, e) potential curve [3]

2. Experimental part

Describe in your own words, how the experiment was conducted, what were the elements in the measuring station, which formulas and constant values were used, and if any assumptions were made. Define all of the values used in formulas and abbreviations. An exemplary description was given in paragraph below.

The measuring unit consists of 8 photovoltaic modules located on the south-east building facade of Chemistry C Gdańsk University of Technology, inverter and data recorder Fronius Datalogger Card with Sensor Box, which enables data transfer to Fronius Solar.web application. Device sensors register solar radiation, module temperature, ambient temperature, generated electricity, DC and AC voltage and current. The whole system is designed so that it is possible to expand it and add components, as presented in figure 2.1.

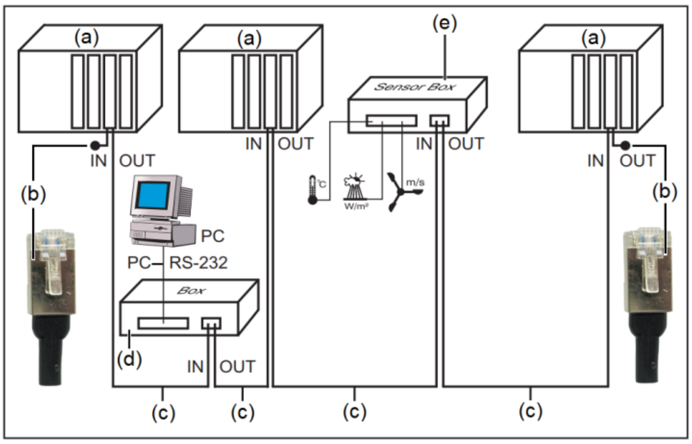

Fig. 2.1. a) Inverter equipped with Fronius system, b) terminal resistor, c) data exchange wire, d) data recorder, e) Sensor Box placed in the external encasement [4]

By using the value of average daily irradiation H(90) and formula (1) – (2), calculate average monthly and daily energy (E_M and E_D respectively) produced by the photovoltaic installation, including 10% all-year-long efficiency. For further calculations it was taken into account that data concern 2 kWp installation, and n means the number of days in chosen month, thus it is necessary to convert obtained values to 1 kWp.

$$E_M = H(90) \cdot S \cdot 30 \cdot 10\% \tag{1}$$

$$E_D = \frac{E_M}{n} \tag{2}$$

3. Results and discussion

This part of the report should include graphs drawn based on carried out measurements. The trend line needs to be included, if there are values to be read directly from relation. If there is no characteristic to draw in current experiment, values are to be presented in table, just like in paragraph below.

Data obtained from Fronis application was used to draw a graph weekly data set representing changes in solar irradiance and energy sent back into the grid as a function of time (figure 3.1).

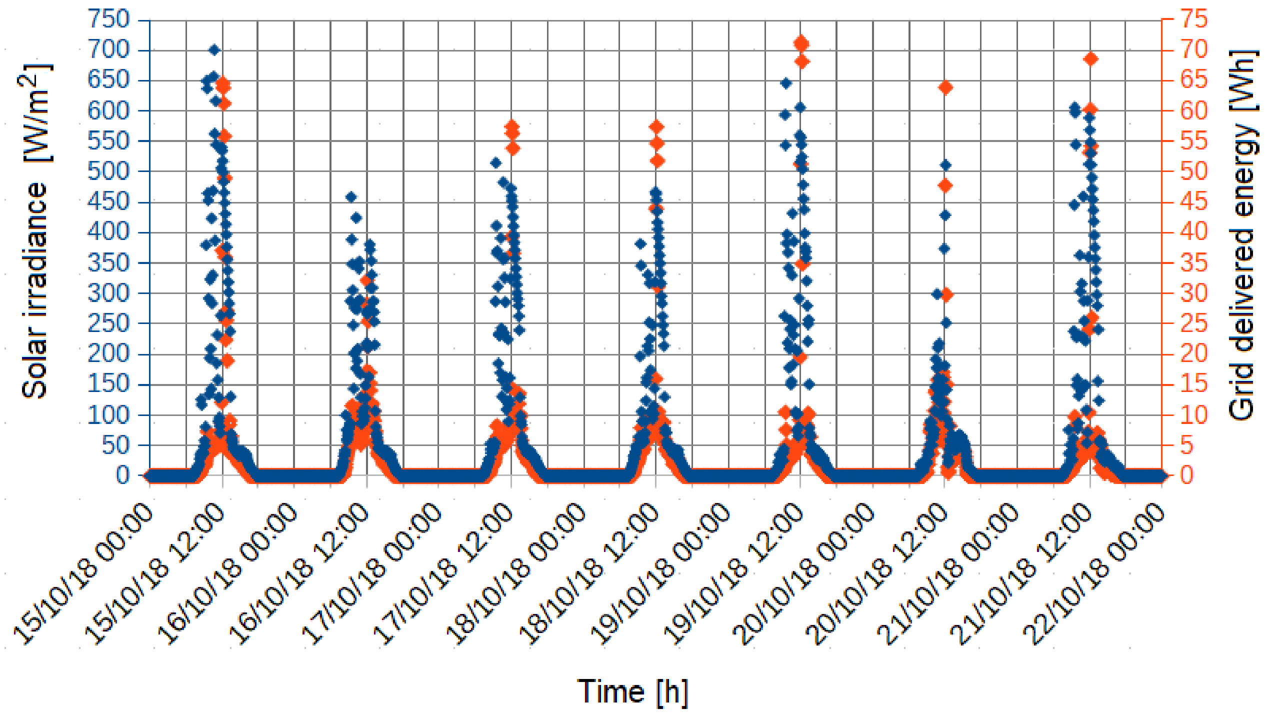

Fig. 3.1. Solar irradiance (blue colour) and energy sent out to grid (orange colour) as a function of time. Graph drawn up from weekly rapport data for time-frame 15 – 21.10.2018

All of the obtained results – from Fronius application, PV-GIS system and calculations, are presented in table with a distinction being made between 2 kWp and 1 kWp installation. Because of weather limitations [5 – 8] values in table 2 are based on chosen week and one single day, when PV installation produced the most energy.

Tab. 3.1. Average daily (H(90)) irradiation, maximum daily (E_D) and weekly (E_W) energy produced by photovoltaic installation in October. Day 16.10.2018 and week 15 – 21.10.2018 were chosen from Fronius application.

	For 2 kWp installation			**For 1 kWp installation**		
	Fronius	*PV-GIS*	*Calculations*	*Fronius*	*PV-GIS*	*Calculations*
H(90) [Wh/(m²·day)]	1299,98	2670,00	2670,00	1299,98	2670,00	2670,00
E_W [kWh]	20,02	100,00	103,24	10,01	50,00	51,62
E_D [kWh]	0,65	3,24	3,33	0,33	1,62	1,66

4. Conclusions

Conclusions should contain values and any correlations that could be derived from graphs. It is crucial to comment experiment results with regard to literature data. If there is a mismatch between them, it ought to be analysed and explained by identifying a reason that could cause measurement disturbance.

Literature:

[1] Paul Hersch, Kenneth Zweibel, Basic Photovoltaic Principles and Methods, Solar Energy Research Institute, Colorado 1982.

[2] Ewa Klugmann-Radziemska, Fotowoltaika w teorii i praktyce, Wydawnictwo BTC, Warszawa-Legionowo 2009.

[3] Piotr Grygiel, Henryk Sodolski, Laboratorium Konwersji Energii, Wydział Fizyki Technicznej i Matematyki Stosowanej, Politechnika Gdańska, 2014, s. 25-41.

[4] Fronius Datamanager. Galvo – Symo – Primo – Eco. Monitorowanie instalacji. Fronius.

[5] Ocena aktualnej i prognozowanej sytuacji meteorologicznej i hydrologicznej na okres 05 - 08.10.2018, Instytut Meteorologii i Gospodarki Wodnej, Warszawa 05.10.2018

http://pogodynka.pl/http/assets/products/download/20181005_Prognoza_weekend.PDF

[access: 30.01.2019]

[6] Ocena aktualnej i prognozowanej sytuacji meteorologicznej i hydrologicznej na okres 12 - 15.10.2018, Instytut Meteorologii i Gospodarki Wodnej, Warszawa 12.10.2018

http://pogodynka.pl/http/assets/products/download/20181012_Prognoza_weekend.PDF

[access: 30.01.2019]

[7] Ocena aktualnej i prognozowanej sytuacji meteorologicznej i hydrologicznej na okres 19 - 22.10.2018, Instytut Meteorologii i Gospodarki Wodnej, Warszawa 19.10.2018

http://pogodynka.pl/http/assets/products/download/20181019_Prognoza_weekend.PDF

[access: 30.01.2019]

[8] Ocena aktualnej i prognozowanej sytuacji meteorologicznej i hydrologicznej na okres 26 - 29.10.2018, Instytut Meteorologii i Gospodarki Wodnej, Warszawa 26.10.20

http://pogodynka.pl/http/assets/products/download/20181026_Prognoza_weekend.PDF

[access: 30.01.2019]