

TO USE A MICROCONTROLLER SYSTEM IN A HOME ENERGY MANAGEMENT

Eng. L. Dan MILICI, PhD¹, Eng. Bert KINT²,
Eng. Cristine VanLARE, PhD², Eng. Mariana MILICI, PhD¹

¹”Stefan cel Mare” University of Suceava, Romania,

²KAHO Sint-Lieven Gent, Belgium,

REZUMAT. O politică energetică bună implică o bună gestionare a surselor regenerabile de energie sau un control al consumului energetic astfel încât să minimizăm consumurile. Lucrarea prezintă un sistem de dezvoltare ce implementează un management al energiei într-o locuință individuală, sistem care poate fi extins ulterior pentru blocuri de apartamente. Acest sistem poate fi integrat în timpul construcției sau în lucrări de renovare. Primul pas este de a economisi energie, pentru a reduce cererea. Principalul avantaj este reducerea cheltuielilor deoarece timpul de amortizare a investițiilor de bază este de cele mai multe ori scurt.

Cuvinte cheie: management energetic, energie regenerabila, sistem fotovoltaic, microsistem de monitorizare.

ABSTRACT. A good energy policy can involve several things, like a good management of the renewable sources or the control from the heat with as less energy as possible. That’s where this paper goes about, the developing of a management system for energy in an individual house, which can be extended later for apartment blocks. This system can be integrated during the construction or the renovation from a dwelling. The first step is to not spoil energy, to reduce the demand of energy. The biggest advantage is probably that a lot of money can be saved, because the payback time of basic investments is -most of the times- short, that’s nice with the rising energy prices!

Keywords: building, design, flexibility, structures components (Maximum 1 rând)

1. INTRODUCTION

Romania has the second biggest energy intensity of Europe, this is due to several things. The country has a large burden from the past, the communist government invested a minimum in the construction and maintenance of apartments in the city. This implicated low-budget materials and no new implementations of modern techniques and nowadays it results in aging of

equipment, antiquated technologies, high operation costs and a high burden for the environment. After 1989 the government took measures, as proven by the numbers from the ODEX as shown in figure 1. The energy intensity decreased from 1996 to 2005 by 26%. On first sight, it seems a great improvement, but later on in this paper there will be explained why it isn’t such an amazing number. [1]

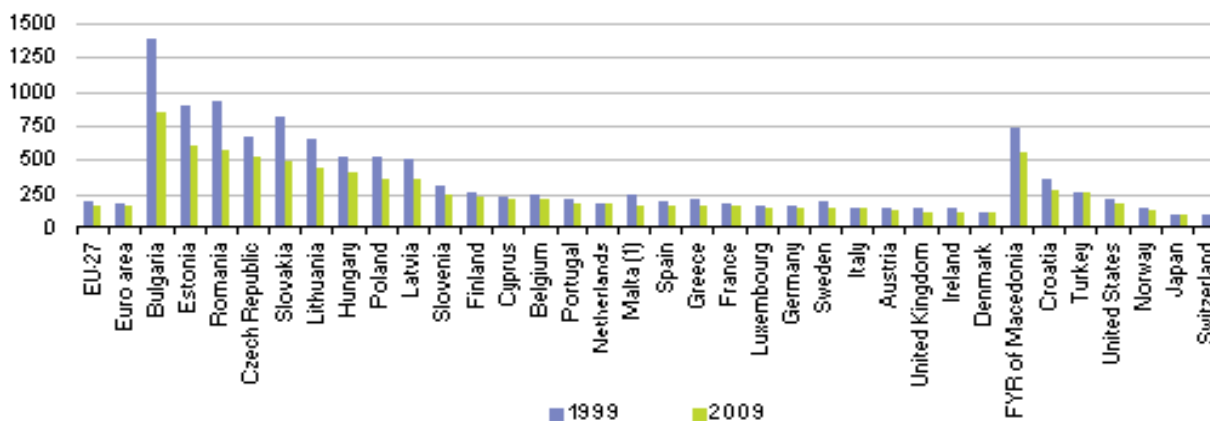


Fig. 1. Consumption energy in Europe between 1999 and 2009 [1]

When talking about energy, energy intensity or energy users, consumers can be split up in three big groups: the industry, residential and rest sector.

According to the statistics from 2009 the industrial group is the biggest, with 43.3% of the total energy consumption in Romania. The industry has a lot of heavy industry with the chemical & petrochemical and iron & steel sector as the two biggest sectors, together they use more than a quarter of all the energy consumption in Romania, so it's evident that big reductions in energy consumption can be made in this sector. The reduction between 1996 and 2005 was nearly 17%, especially the textile and food processing industries made big progresses. There were no big decreases recorded by the two biggest energy groups. [2]

The second biggest sector is the residential sector, thus a lot of reduction possibilities exists. Although, nowadays they still have the second highest energy intensity of Europe, after Bulgaria. The big reduction seems incredible, but it's not; because 1996 was the worst year considering energy intensity in the Romanian households. Measures for improving the performances of the existing buildings have been taken, a few are given in the next sentence. Improved standards for the new dwelling places have been developed, energy labelling of the households appliances, as mentioned in the introducing article. The elimination of subsidies and increases of the energy prices for the population have led to changes in behaviour. [4]

One of the solutions for the ancient technologies - which is also applied- is the installation of cogeneration, dimensioned on the heat or electrical demand. The most common is when the heating -and electrical demand is partly supplied by the cogeneration, additional heating -usually in the winter- is done by a traditional heating system and extra electricity comes from the grid. Obviously, every situation must be viewed individually, especially when you want to make large investments, but the most important thing remains sustainable materials and insulation! [3]

Sometimes the national and local governments join forces to invest in projects. The first one is as mentioned earlier, concerns the thermal rehabilitation of about 300 apartment buildings in Bucharest, this project was developed with help of the European Investment Bank. In Suceava the city hall rehabilitated his heating network and the thermal units. Also there is the intention to modernize three thermal units and the heating pipes in the areas with problems. The local authority's launched in 2011 a dispatcher to coordinate the automated thermal units in order to manage and

detect more easily problems with the heat and hot water supply to the population. Nowadays almost half of the thermal units in Suceava have been modernized with state and local budget.

2. STARTING POINT FOR THE STUDY

There are two main arguments that provide in a good starting point for the study. The first one is the creation of space to reconstruct the very ancient apartment blocks in cities. Therefore movements to other dwellings are required, inter alia to apartment blocks or individual houses. The second reason is if can be saved a lot with a good energy policy, estimated to 45-50 % in 2009. [5]

A good policy can involve several things, like a good management of the renewable sources or the control from the heat with as less energy as possible. That's where this paper goes about, the developing of a management system for energy in an individual house, which can be extended later for apartment blocks. This system can be integrated during the construction or the renovation from a dwelling. [6]

The trias energetica is a beautiful concept, the fossil energy must be saved until there exists no other possibility then using them. The first step is to not spoil energy, to reduce the demand of energy. For example by using enough insulation or by using smart tools that help to decrease your energy consumption. It isn't necessary that the heat works during the day when you're out working or when you're sleeping. In ancient apartment buildings temperatures of 25°C are easily reached, but by implementing some modern equipment it's easy to regulate to 21°C. The biggest advantage is probably that a lot of money can be saved, because the payback time of basic investments is -most of the times- short, that's nice with the rising energy prices! [5]

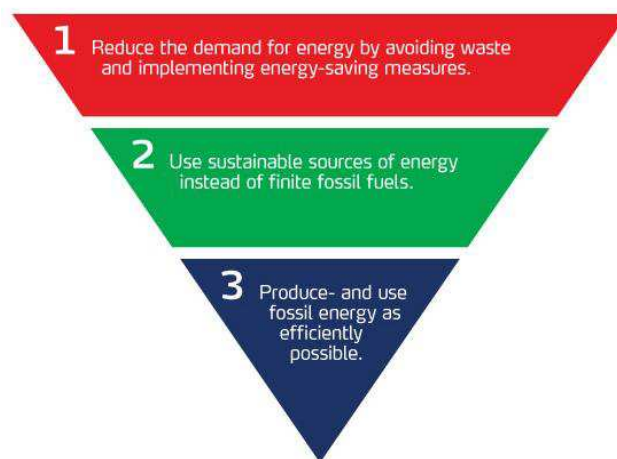


Fig. 2. Trias Energetica [5]

The second step -in the trias energetica- is to use renewable energy, in the model where we work around are three sources available: a windmill, photovoltaic panels and a solar collector. The first one is not appropriate when you want to build with an eye view on your wallet, because of its high investment cost and a long payback period. Although it's worthwhile to mention that Romania has the biggest wind potential all over Western Europe and comes with its Dobrogea Region on the second place of whole Europe, so actually in this region it's worthwhile to investigate the payback time of such an investment. The photovoltaic panels should provide, together with the windmill, the electrical demand of the dwelling, whether or not turned off the grid. In the model there is a battery pack available, so the assumption is made that the house is not connected with the grid, thus the house must provide itself from electrical energy. Although it must be said that the investment in an autonomous system is more expensive because it includes inter alia a battery package and charge controller. The solar boiler is used to provide the house from hot water, as well for sanitary as for heating. [5]

3. EXPERIMENTAL TESTS

As shown on figure 3, the house contains a solar collector, three photovoltaic panels and a windmill. Six temperature sensors are integrated and the voltages generated by the PV-panels and windmill are readable via pins where a flat cable can attach on. The house also contains two batteries, actually they're not required to let the house work properly. In total there are five LED's, from which two attached on the house itself. The three LED's on the floor (in front of the windmill) can light up in green or red.

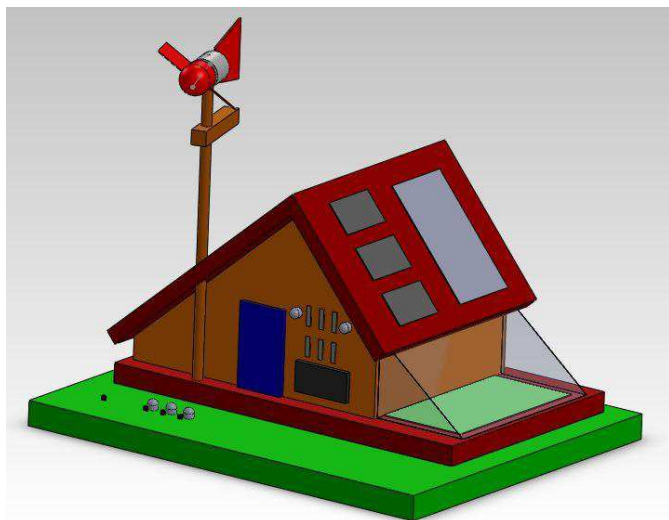


Fig. 3. The house

First of all we made the hypothesis that the house is very good insulated, conform the trias energetica: reducing the demand of energy. Most of the times there is on new, so good insulated, constructions under floor heating, therefore the house is divided in three areas that can be individual heated. This means there are three circulators, accompanied by three valves, to pump the heating water around in the right circuit. Each sector in the house has his own temperature measurement. A fourth temperature measurement is done in the solar collector itself. The solar boiler has to provide in the first heating needs. If the boiler no longer can provide in the heating demand of the house the additional boiler on gas helps to heat. The last two temperature measurements - the exterior temperature and the temperature in the verandah - are just only for information, they are not involved in the algorithm to have a good energy policy in the house.

Next to all these temperature measurements, two voltages are read out: from the PV-panels and from the wind mill. For studying the electrical part of the house, we must make a clear difference between on-grid and off-grid systems. In general, an off-grid system needs an (expensive) battery pack. Hereby the battery pack is fed from the solar panels and windmill, the house is provided from electricity via the batteries. The installation according to an on-grid system is more simple and cheaper. The batteries are not necessary and the choice from the windmill will be different.

There is one kind of output: LED's. LED's on the house and LED's on the BIGPIC4-panel. The LED's on the house indicate several things directed to the sensors, sometimes they also appear as actuator.

Each temperature sensor in front of the windmill, that function as a sensor from a circuit, has one LED that can light up into two colours. Red means that it's too cold in the area and that the heating has to work, when the LED's illumine green it's warm enough in the room.

On the house itself are two LED's. An orange one to indicate if the wind delivers enough energy to provide the house from electricity, the yellow one to indicate when the PV-panels deliver enough energy. Both LED's pink when both energy supplies are not sufficient for the electricity supply, then the batteries supply the house from electricity.

BigPIC4 it's a full-featured development board for Microchip PIC microcontrollers. It has been designed to allow students and engineers to easily exercise and explore the capabilities of PIC microcontrollers. It allows the microcontroller to interface with external circuits, allowing the user to concentrate on software development. In this project is used analog inputs, digital outputs, the 2x16 LCD display, the buttons and the SD card. Other features are the PS/2 connection, 2

RS232 ports, USB-connection...

Following indicating LED's are on the BIGPIC4-board, they're more or less the actuators. Three LED's (according with the three circuits) for each circulator/pump and accompanying valve. According the stand of the switch that is indicated with the LED on the board, the batteries are whether or not recharging from the windmill and photovoltaic panels. Recharging happens when the voltage from the windmill and PV-panel together is higher than e.g. 2.5V. A LED for when the gas boiler has to work, this happens when the solar boiler cannot support the heating demand.

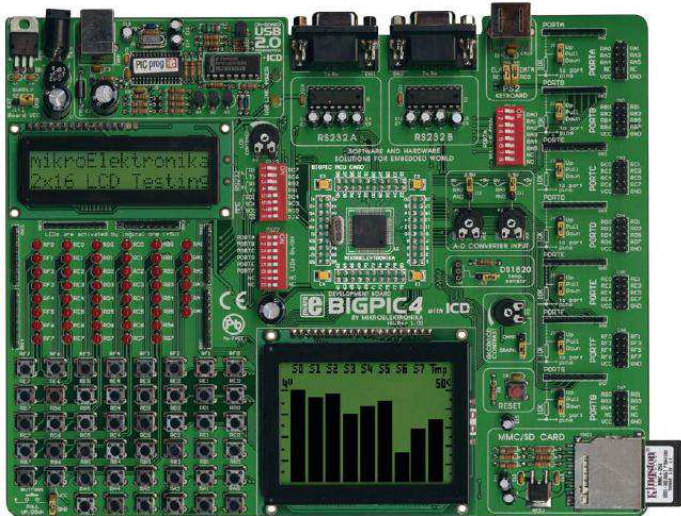


Fig. 4. bigPIC4 development board [7]

The timer is essential to make periods of 15 minutes, every period a signal is given to write a set of values to the SD-Card. [7]

The PIC 18F8520 contains five different timer modules. In this project is chosen for the timer 2 module. Timer 2 contains inter alia an 8-bit (28 = 256) period register (PR2) and a software programmable prescaler and postscaler. The algorithm uses three variables: sec, min and a flag. Every second sec increments, if sec reaches the value of 60, it will reset himself (to restart counting) and increments min. Every 15 minutes the flag is set high and min resets to restart counting. Each cycle (great order is less than 1 second) the main checks if the flag is high, in case of a high flag the write action to the SD-card occurs, afterwards the flag resets.

The hardest part is to make exactly one second, the explanation is done with an example. Suppose that the oscillator works at 40 MHz, then takes each cycle 25 ns. The timer modules work with the frequency divided by four (10 MHz), so a clock cycle takes 100 ns or 0.1 us. The prescaler and postscaler are a kind of delays, for example with the prescaler on 1:2 (and the assumption that PR2 = 1) an interrupt will appear every 200ns, the

same story with the postscaler. The project uses a postscaler from 1:10 and a prescaler from 1:16, that makes 16us for one pulse. A fourth variable is created, subsec, it increases every 250 pulses, 250 is the configuration of PR2. So every subsec takes 4ms. To make one second, subsec (=4ms) has to be increased 250 times: 1s.

Beneath are shown the register for the configuration of the scalers and the schematic representation from the scalers, both come out of the manual of the PIC 18Fxx20 series. The first one handles the settings of the T2CON register, this register is important for the configuration of the prescaler and postscaler. Figure 6 shows how the scalers are implemented into the controller. In the following the determination of the parameter-word for T2CON is explained with aid of the manual; it's the only case in the paper where such a thing is described extensively, further on will be referred to the annex. Let's continue working with the example of 40 MHz, in the project are used a prescaler from 1:16 and a postscaler from 1:10. Figure 5 shows that bit7 of the T2CON-register is not used, the third till sixth (T2OUTPx) bit are reserved for the postscaler, in this case (1:10) we have to fill in 1001, the second (TMR2ON) must be zero and the two first bits (T2CKPS) must have the value 1x (x = doesn't matter) for the prescaler of 1:16. Adding all previous bits together we get 0100 101x, or 4A (also 4B) in hexadecimal code. [8]

REGISTER 13-1: T2CON: TIMER2 CONTROL REGISTER

| U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|-------|----------|----------|----------|----------|--------|---------|---------|
| — | T2OUTPS3 | T2OUTPS2 | T2OUTPS1 | T2OUTPS0 | TMR2ON | T2CKPS1 | T2CKPS0 |
| bit 7 | | | | | | | bit 0 |

- bit 7 **Unimplemented:** Read as '0'
- bit 6-3 **T2OUTPS3:T2OUTPS0:** Timer2 Output Postscale Select bits
 - 0000 = 1:1 Postscale
 - 0001 = 1:2 Postscale
 - .
 - .
 - 1111 = 1:16 Postscale
- bit 2 **TMR2ON:** Timer2 On bit
 - 1 = Timer2 is on
 - 0 = Timer2 is off
- bit 1-0 **T2CKPS1:T2CKPS0:** Timer2 Clock Prescale Select bits
 - 00 = Prescaler is 1
 - 01 = Prescaler is 4
 - 1x = Prescaler is 16

Fig. 5. Configuration of the scalers for T2CON register. [8]

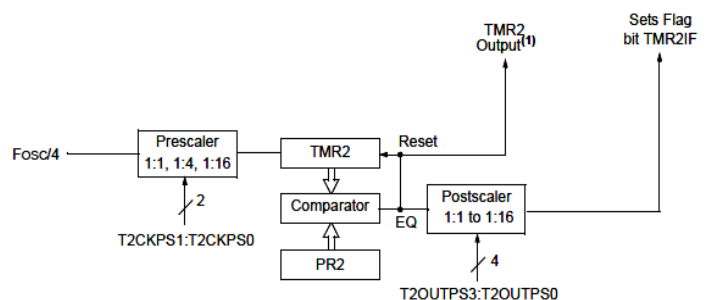


Fig. 6. Schematic representation of the timer 2 module and its delays. [8]

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Hereunder is given the syntax necessary to implement the timer in the program. The main creates

interrupts every 4ms. The interrupt procedure handles the counting of subseconds, seconds and minutes.

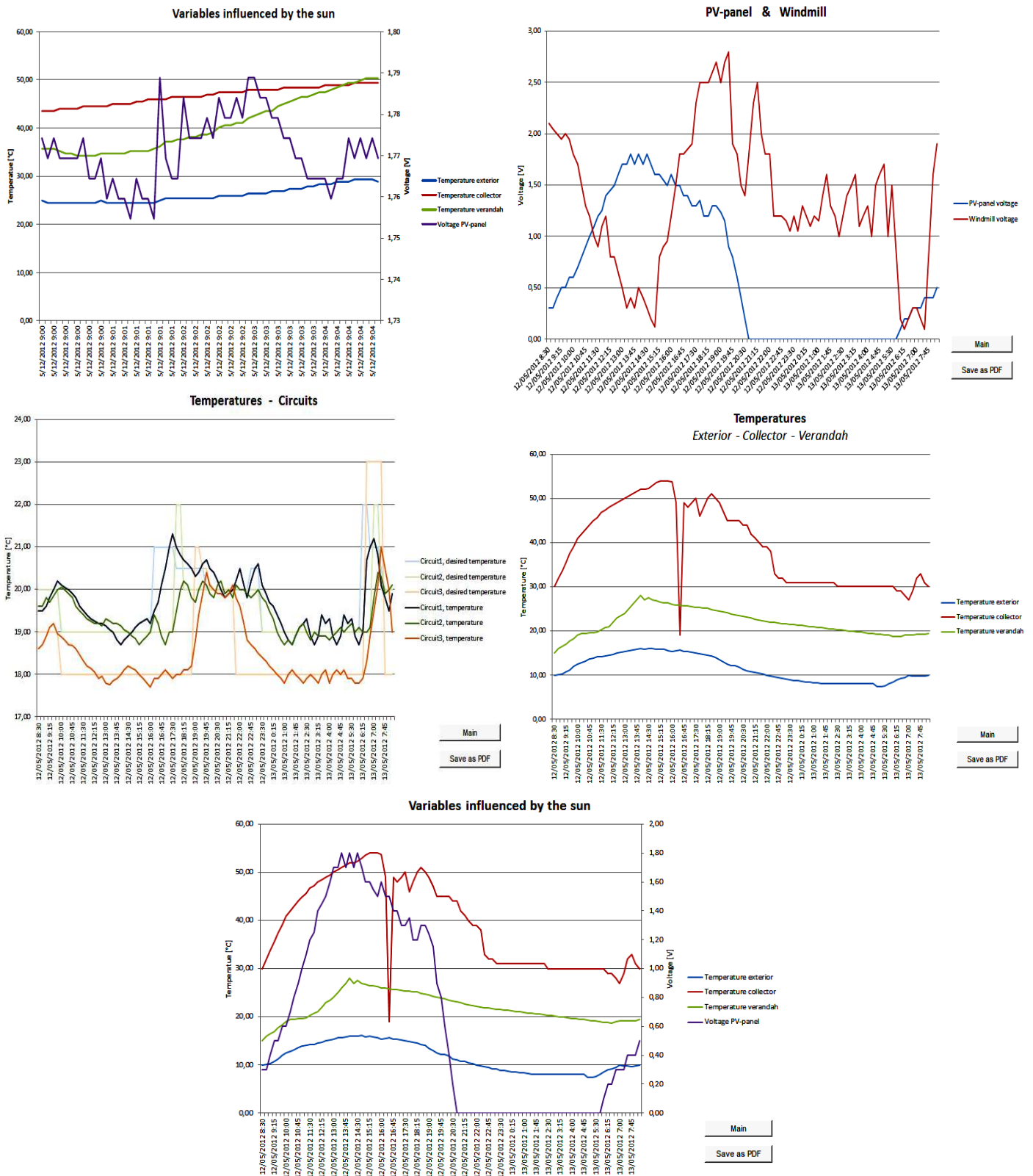


Fig. 7. Experimental data

It's almost impossible to perform tests with the setup of the example house, therefore different reasons are responsible. The temperature sensors for the three circuits stand physical next to each other, so it's hard to change the temperature of one circuit without changing the other temperatures. A second reason is that the solar collector is not heating up like a real one is supposed to do, also another measurement for the heated water from a collector should be done in the boiler. A third reason is that the verandah temperature goes easily to 50°C and more, this is due the material (plastic). Another reason is that if it was possible to have high temperatures with the boiler and a circuit needs heating water, then the algorithm decides that first the hot water has to be taken out of the boiler (collector). Then the temperature in the boiler/collector should decrease, but here it's quite impossible to simulate this circumstance. The most important reason is that you're not able to accompany the setup for instance 48 hours, so all the temperature measurements will be approximately the same, especially the exterior temperature and the three circuits because they're standing next to each other, also there will be never wind... at least you don't make it yourself.

Even if you try to do some tests, it's designated that you change the sampling time, for example from 15 minutes to 5 seconds. This change is easy performed by changing the syntax in mikroBasic, one "minute" only takes 5 seconds and every 1 "minute" a sample is recorded.

Figure 7 comes from a measurement outside, it only confirms what is discussed above. Within a few minutes the verandah temperature goes to more than 50°C. It confirms that performing tests are quite impossible.

4. CONCLUSIONS

As mentioned already earlier, the concept of such systems is good, so it's worthwhile for further study. For example you can design a very cheap modal to commercialize with power measurements, this was discussed in the previous paragraph. Also would it be

easy if you could insert schedules for programming the desired temperatures in each circuit, for example for during the night. Another proposal could be to make the existing program more ingenious, for instance with the input of a keyboard through PS/2 connection, a live stream through USB-wire, additional temperature measurements whereat you can chose the amount of circuits (areas in the house) you can use. The last idea is also a good proposal for the commercialization of the project, so you are able to insert the amount of circuits from the house. Another proposal could be to investigate the power consumption of the microcontroller and its peripherals, but even without knowing the results it is obvious that the consumption of the microcontroller and its peripherals is many times smaller than the savings that they achieve.

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