ENERGY EFFICIENCY CONTROLLED BY ARDUINO MODULES

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Abstract*: To control and reduce energy consumption, it demands to install a network of sensors and using a dashboard to monitoring data acquisition from its. Energy monitoring is necessary to keep track of energy consumption according to the season, weather conditions and the flow of use of electrical appliances in the institution. The paper presents an approach for monitoring energy efficiency base on Arduino modules (smart-MAC) through a dashboard application. Dashboard WEB application has the advantage of leting the user a flexible indicator and chart widgets configuration for create an unlimited number of boards and devices connected to the same account. To realize an efficiency use of energy in public institution the date is analyze and on results can be take measurements for it.*

1. INTRODUCTION

The European Commission suggested to Romania to define more ambitious objectives and targets regarding integration in the internal energy market, recommending the adoption of certain measures to develop liquid and competitive wholesale and retail markets. Romania has recently taken significant steps in this respect, also undertaking to follow a liberalisation calendar that will ensure free pricing as of 2020/2021 depending on the demand and offer. On the other hand, the operationalisation of the support measures for vulnerable consumers and

the alleviation of energy poverty will be considered in strict correlation with the deadlines of the abovementioned calendar.

In the updated version of the Plan, Romania also clarifies the undertaken target regarding the level of interconnectedness of energy transmission grids, which will reach at least 15.4 % in 2030 based on a progress calendar for current and projected projects, which is administered by the energy transmission system operator.

Moreover, Romania is involved in the European process of integration of energy markets in the context of achieving the Single Day-Ahead Coupling (SDAC) and the Single Intra-Day Coupling (SIDC), involving the corresponding contractual framework. As regards research, innovation and competitiveness, the Romanian Government plans to prepare the National Smart Specialisation Strategy for the period 2021-2027, which is foreseen to be published in the second quarter of 2020. The strategy intends to define the national objectives and targets of funding in the fields of research, innovation and competitiveness, thus addressing the Commission's recommendation.

In conclusion, Romania has initiated various actions with the purpose of increasing the level of ambition as regards the RES share and the energy efficiency targets and is considering several measures to define and to implement strategies and policies that concern reaching the targets committed to, some from these are: decarbonisation - GHG emissions and removals and renewable energy; energy efficiency and security; development internal energy market and research, innovation and competitiveness of technologies contributing to decarbonisation. [1]

2. POTENTIAL FOR USE OF ENERGY-EFFICIENCY AND RENEWABLES

Due to availability of natural resources, the use of renewable energy sources to satisfy different human needs has long tradition in Romania. For centuries Romanians have been used wind and water to put in force mills, wood and solar energy to heat water and houses. The concerns for promoting renewable energy are dated since 1970s, Romania being a pioneer in this field [2]. One effect of the former communist state collapse was the decrease of public investments in the field, leading to the stagnation of the renewable energy sector development.

Being endowed with so many natural resources, Romania is a country with a high renewable energy potential. The type of resources and the energy potential of each are summarized in Table 1. An important problem is determined by the gap between the theoretical potential and the technical and economical feasible potential. Thus, the RES primary production in 2011 was 5028 ktoe, divided in 3618 ktoe biomass energy, 1266 ktoe hydro energy, 120 ktoe wind energy and 24 ktoe geothermal energy [3].

Table 1 Energy potential of renewable energy sources. Source: ANRE [4].

Renewable energy source	Annual energy potential	Economic energy equivalent (ktoe)	Application
Solar energy			
- thermal	$60*10^6$ GJ	1,433.0	Thermal energy
- photavoltaic	1,200 GWh	103.2	Electrical energy
Wind energy	23,000 GWh	1,978	Electrical energy
Hydro energy (total)	40,000 GWh	3,440.0	Electrical energy
- under 10 MW	6,000 GWh	516.0	Electrical energy
Biomass	$318*10^6$ GJ	7,594.0	Thermal energy
Geothermal energy	$7*10^6$ GJ	167.0	Thermal energy

Romania is pursuing renewable energy sources in three different directions:

• Electricity (RES-E). The renewable energies used to produce electricity are wind, hydropower, solar photovoltaic and bio- mass. In 2011 the electricity produced from renewable sources achieved 20673 GWh [4] leading to a share of RES-E in total gross electricity consumption of 27.05% [3]. The number of RES-E licensed producers in 2011 was 82 (of which 42 use wind energy, 32 hydro energy, 4 biomass energy and 4 photovoltaic energy) [4]. Hydro plants produce a very high share of RES-E (Table 2).

Table 2 RES-E production (2011). Source: ANRE [4].

RES-E technology	GWh
Photovoltaics	2
Solar Thermal	0
Wind on-shore	290
Winf off-shore	0
Hydro large scale	18,992
Hydro small scale	1,273
Biomass	118
Biogas	0
Geothermal energy	0
Total	20,675

• Heating/cooling (RES-H). As not all renewable sources have the same potential to provide in heat, the Romanian renewable energies most suited for heating and cooling are: biomass, geothermal and solar resources. Table 3 shows the share of each technology in RES-H production in 2010. Biomass contributes considerably to Romania's heat production and

consumption. These levels are the result of the high use of forestry products for heating. About 95% of the biomass resources are used in private households for heating, cooking and hot water preparation, the remaining being used by industry [5].

Table 3 RES-H production (2010). Source: ANRE [4].

RES-H technology	ktoe
Biomass	415
Solar thermal	5
Geothermal energy	18
Renewable energy from heat pumps	8
Total	**446**

• Transportation (RES-T). The country's intention to comply with the Kyoto Protocol require, among other measures, an increased use of biofuels for transport. In Romania, biofuels are obtained by processing the rape, corn, sunflower and soybean crops. Although Romania has a huge potential in terms of energy crop production, biofuels production registered very low levels (163 ktoe) [6].

Although these levels are significantly higher than the average of EU-27, the energy is obtained mainly from conventional renewable sources (large hydro and biomass) rather than through green renewable sources. [7].

3. SENSORS IN BUILDING MONITORING

3.1. Temperature sensor

You can connect up to 5 pcs DS18b20 temperature sensors or one DHT22 temperature and humidity sensor to the universal smart-MAC D105 meter. [8] DS18b20 are digital 1-Wire temperature sensors, all of them are connected to one contact, terminal 4. Black (or White) wire all sensors combine and connect to terminal 1: GND (Ground or -5B). Red wire all sensors combine and connect to the terminal 6: 5B. Yellow (or Blue) wire all sensors combine and connect to terminal 4: Data 1-Wire.

Temperature sensors such as DS18x20 can be connected by 3 wired circuit (described in *fig. 1*) or 2 wire. Pay attention, there are many low-quality sensors on the market that work unsustainably not only on the 2-wire circuit but also on 3 wired when connecting more than one sensor. The sensors from our store are of proven quality and work sustainably on any connection scheme.

When connecting multiple Sensors such as the DS18x20, they all need to be connected the same way, using a 2 or 3 wired connection.

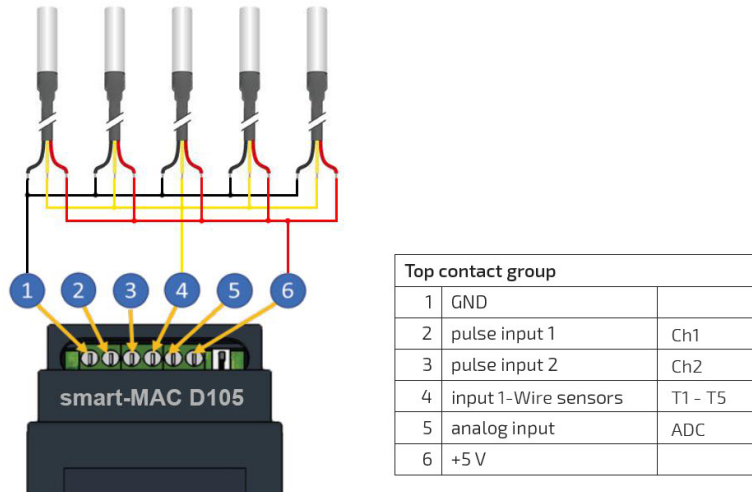| Top contact group		
1	GND	
2	pulse input 1	Ch1
3	pulse input 2	Ch2
4	input 1-Wire sensors	T1 – T5
5	analog input	ADC
6	+5 V	

Figure 1 3-wire connection to smart-MAC D105 [9]

3.2. Counters (flow meters) with impulse output

It can be meters for water, gas, heat, fuel, milk, beer and many others. Two types of impulse outputs must be distinguished: The meter with a impulse output of the type "Dry contact" (mechanical meters). The meter with a impulse output of the type "n-p" (electronic meters).

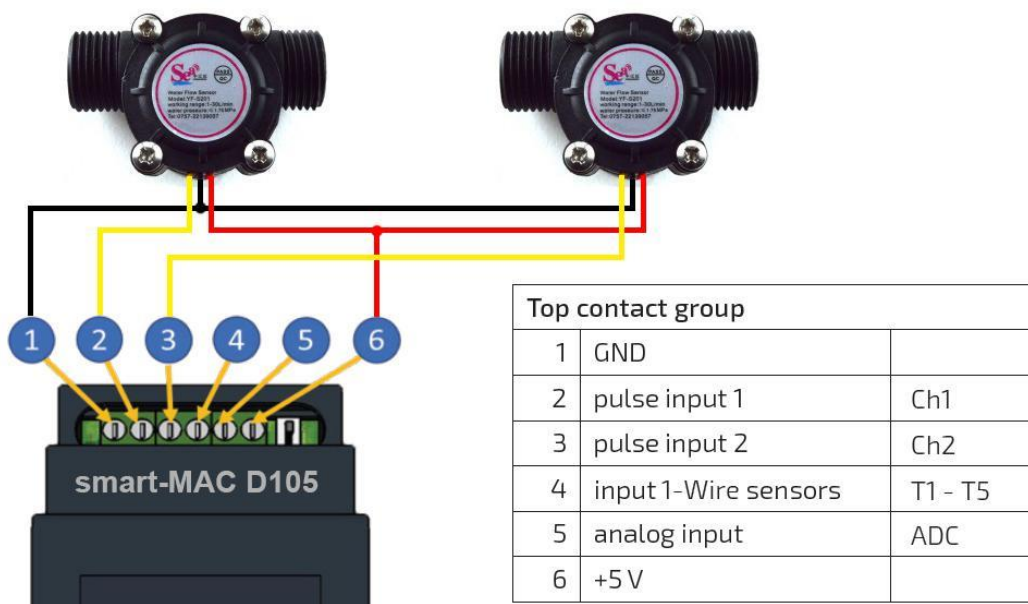| Top contact group		
1	GND	
2	pulse input 1	Ch1
3	pulse input 2	Ch2
4	input 1-Wire sensors	T1 – T5
5	analog input	ADC
6	+5 V	

Figure 2 Three-wire circuit for connecting a flow meter to smart-MAC D105 [10]

3.3. Wind Speed and Wind Direction sensors

The Wind Speed and Wind Direction sensors (figure 3) can be connected to the universal D105 meter. Wind speed and wind direction sensors transmit information via the RS485 bus. This interface is notable for its stable working at large distances, up to 100 meters. Through the

RS485-1Wire interface, which comes in a box from smart-MAC only, the sensors are connected to the digital input (4) of the smart meter smart-MAC D105. Specify the colors of the wires in the description for the sensor. [11]


Figure 3 Speed and Wind direction sensors

3.4. Monitoring interface for Arduino modules

The monitoring system is created on the basis of "smart" devices of energy monitors of the Ukrainian company smart-MAC (https://smart-mac.com/) and data obtained in the course of the monitoring process are available for viewing in real time on any device (PC, tablet, smartphone) and stored for further analysis in the cloud storage.

The obtained data on actual energy consumption, after the installation of the pilot monitoring system, during the calendar year will allow to estimate the specific thermal characteristics of the building, determine the actual energy consumption to ensure regulatory microclimate in the building, assess the rationality and trends of energy consumption. Also, such data will help to assess the real effect after the implementation of energy efficiency measures to reduce energy consumption in university buildings.

a)   *b)*
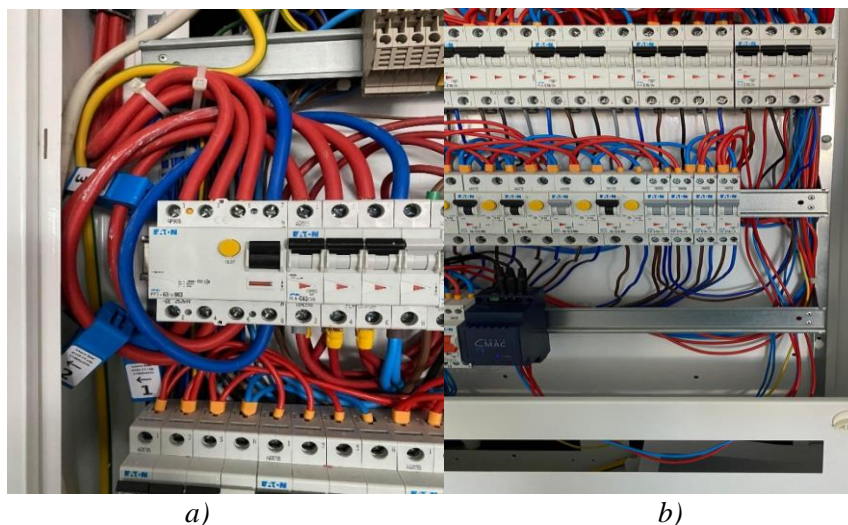
Figure 4 - Reconstruction of the electrical distribution cabinet

The pilot energy monitoring system for the university building is being deployed on the basis of the Department of Electric, Electronic and Computer Engineering of TUCN-NUCBM. The Department of Electric, Electronic and Computer Engineering occupies a third part of the academic building C of the university and is located on one floor of the building.

Installation of Building Management System (BMS) will allow to maintain a balanced energy consumption through detection of electricity consumption, temperature losses, monitoring of utilities and data storage on each area where are installing the sensors, and also, calculating the specific consumption much more accurately.

For each room and node of energy consumption measurement its own page in the web application with digital and graphic representation of character of the current data of energy consumption and change of energy consumption during observation time (figure 5) is developed.
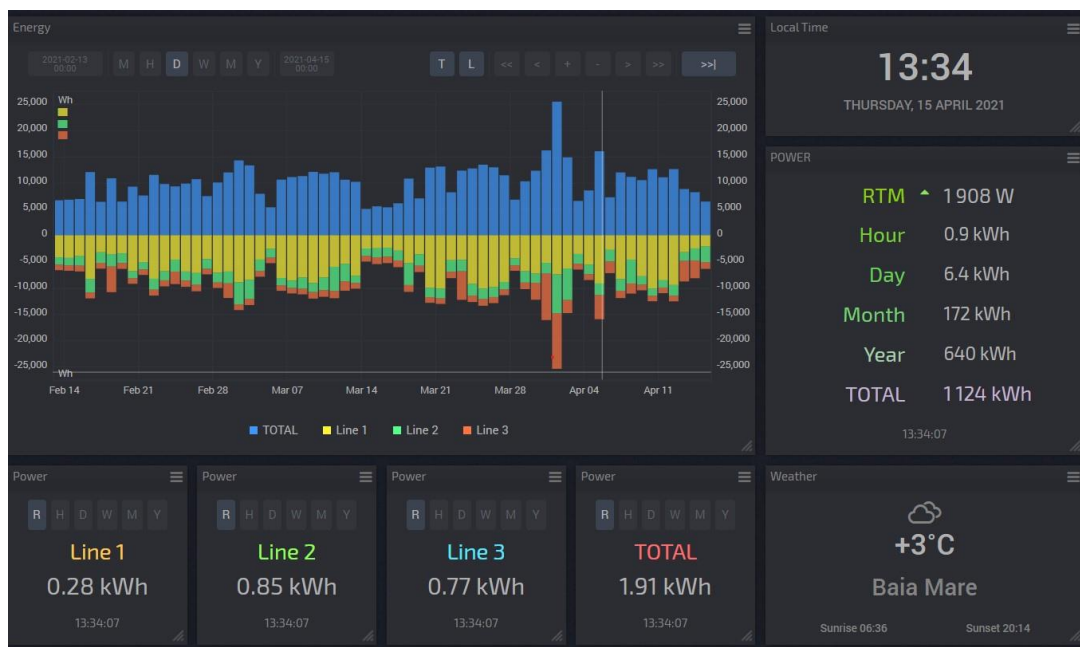

Figure 5 - Display of energy consumption and microclimate parameters

4. CONCLUSIONS

Energy monitoring is necessary to keep track of energy consumption according to the season, weather conditions and the flow of use of electrical appliances in the institution. The universal WEB application smart-MAC Dashboard base on Arduino modules, to monitor the sensors give the main advantage for flexibly configure indicator and chart widgets and create an unlimited number of boards and devices connected to the same account.

The user is able to be flexible to configure indicator and graph widgets; create an unlimited number of cards and devices connected to the same account; provides easy

monitoring of the sensors used; monitoring of sensors for reduce consumption and quite significant energy consumption costs.

Energy management in public institution depends by the control and monitoring of energy consumption and demands network sensors and dashboard to monitoring data acquisition from network create. After an analyze of date can be take measurements for efficiency use of energy in public institution.

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