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Energy Monitoring System

P. Ebenezer Paul[1], S. Nagraj[2]
Narasu's Sarathy Institute of Technology, Poosarapatty, Salem-636305

I. INTRODUCTION

Energy management is the means to controlling and reducing your organization's energy consumption... And controlling and reducing your organization's energy consumption is important because it enables you to:
Reduce costs – this is becoming increasingly important as energy costs rise. Reduce carbon emissions and the environmental damage that they cause - as well as the cost-related implications of carbon taxes and the like, your organization may be keen to reduce its carbon footprint to promote a green, sustainable image. Not least because promoting such an image is often good for the bottom line. Reduce risk – the more energy you consume, the greater the risk that energy price increases or supply shortages could seriously affect your profitability, or even make it impossible for your business/organization to continue. With energy management you can reduce this risk by reducing your demand for energy and by controlling it so as to make it more predictable.
On top of these reasons, it's quite likely that you have some rather aggressive energy-consumption-reduction targets that you're supposed to be meeting at some worrying point in the near future... Your understanding of effective energy management will hopefully be the secret weapon that will enable you to meet those aggressive targets...lets see the energy monitoring system in detail for solar pv cell.

II. EMS(Energy Monitoring System)

Energy monitoring system(EMS) is an energy efficiency technique based on the standard management axiom stating that "you cannot manage what you cannot measure". M&T techniques provide energy managers with feedback on operating practices, results of energy management projects, and guidance on the level of energy use that is expected in a certain period. Importantly, they also give early warning of unexpected excess consumption caused by malfunctions, operator error, unwanted user behaviors, maintenance errors and the like.The foundation of M&T lies in determining the normal relationships of energy consumptions to relevant driving factors (production though puts, weather, available daylight, etc.) and the goal is to help business managers:

A. Identify and explain excessive energy use
B. Detect instances when consumption is unexpectedly lower than would usually have been the case
C. Draw energy consumption trends (weekly, seasonal, operational…)
D. Determine future energy use when planning changes in the business
E. Diagnose specific areas of wasted energy
F. Observe how the business reacted to changes in the past
G. Develop performance targets for energy management programs
H. Manage their energy consumption, rather than accept it as a fixed cost that they have no control over.

The ultimate goal is to reduce energy costs through improved energy efficiency and energy management control. Other benefits generally include increased resource efficiency, improved production budgeting and reduction of greenhouse gas (GHG) emissions. M&T is an established technique that that was first launched as a national program in the UK in 1980, and has since then spread throughout Europe. Its reputation is now also slowly growing in America.

III. SOLAR PV MONITERING SYSTEM

This page accompanies the main open energy monitor guide which details the main step by step process of building an open energy monitor system.
This page documents application specific notes on building a wireless web-connected solar PV monitoring system that monitors both generation and grid import/export.

As detailed in the main guide an open energy monitor system comprises of wireless sensor nodes that send data at periodic intervals to a web-connected base-station. The wireless sensor node that is used for the solar PV monitor is the multi purpose board called the emontx.

A low power wireless energy monitoring node. It's designed to sense data from multiple CT current sensors, optically from a pulse-output utility meter and from multiple one-wire temperature sensors. It can be powered by 2 x AA batteries or 5V USB

Plugged into the emontx are two clip-on CT current sensors and an AC-AC plug-in voltage adapter are used to sense the solar PV generation and consumption. It is possible to sense the LED pulses from a pulse output utility meter to monitor the power flow, however CT sensors give a much better quality reading of instantaneous power. When monitoring power using the pulse counting method the sample rate is limited to the number of pulses, at low power values the rate of pulses can be extremely long.

Select the current and voltage emontx firmware when you reach the upload the configuration specific firmware step of the main open energy monitor guide.

A. Installation of emonTx

How the CT sensors are connected installed depends on how the solar PV system has been installed. For sake of reference we have called these systems type 1 and type 2.

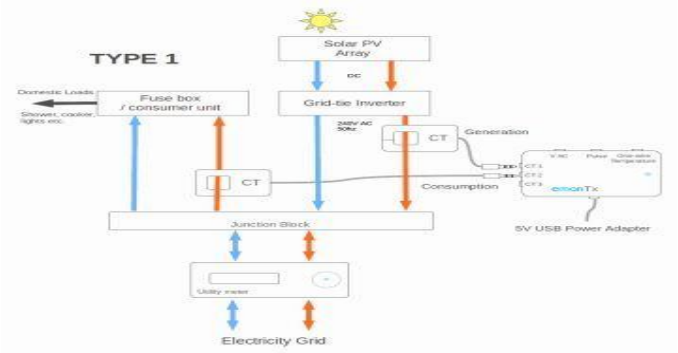


Fig.1- type 1

Type 1

When the generation and consumption can be monitored separately. The amount exported/imported to or from the grid is simply

the excess or deficit of the total of generation minus consumption. Knowledge of the direction of the current is not required therefore a plug-in AC-AC voltage sensor adapter is not essential but still recommended for accurate readings. For a type 1 solar PV monitoring system the grid import/export is calculated as follows: " Grid (import/export) = Consumption – Generation". Consumption and Generation should be positive, reverse orientation of clip-on CT sensor if not. Grid calculation will be positive when importing and negative when exporting.

Type 2

When the generation and consumption cannot be monitored separately, i.e the AC output from the solar PV inverter is fed into a spare MCB in the fuse box. Other household loads such as lights, shower, electric cooker etc. are also connected to other outlets in the same fuse box. If this is the case the output from the PV inverter and the grid import/export connection will need to be monitored instead. Knowledge of the direction of the current is required to determine the difference between power import and power export. Therefore an AC-AC voltage sensor adapter is essential.

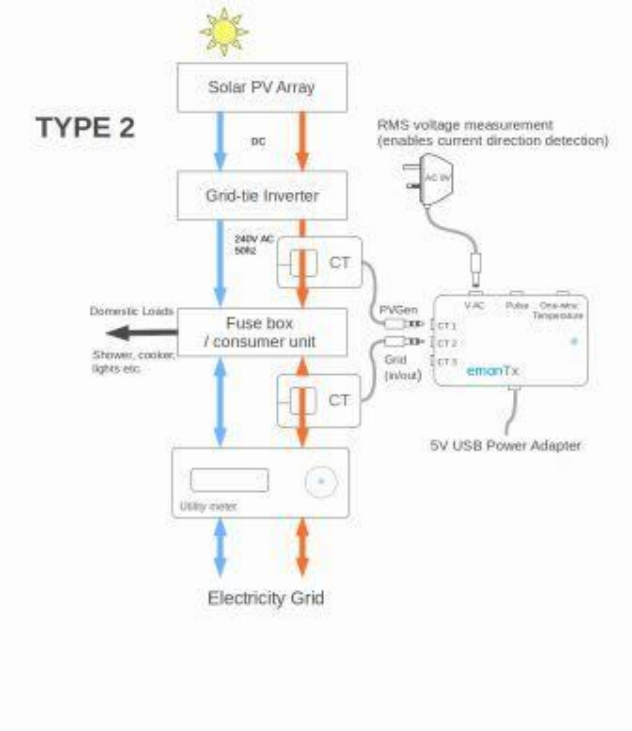


Fig.2 - type 2

When the AC-AC voltage sensor is used (see below) the grid import/export CT reading will go negative when exporting or vice-versa depending on the orientation of the CT clamp round the wire. To be compatible with the software examples included with this documentation it is desirable to clip the CT round the grid import/export cable orientated so that the reading is positive when importing and negative when exporting. The correct orientation can be determined by trail and error. Household power consumption can be calculated in software:

Power consumption = Solar PV generation + Grid import/export (negative when export)

B. AC-AC voltage sensor adapter

In order to determine the direction of the current flow (important for being able to tell the difference between grid import or export) an AC voltage reading is needed to provide a point of reference; this result is a positive or negative current current reading depending on the direction of the current and the orientation of the CT clamp.

The emonTx obtains a voltage reading using an AC-AC 9V plug-in transformer. Using this adapter also allows us to monitor

the RMS AC voltage, real power and power factor. For information about how the AC-AC adapter and AC RMS reading works see relevant section in Building Blocks. A nearby power socket is required for the AC-AC adapter.

Note: The emonTx cannot currently be powered from this AC-AC adapter. Rectifying and loading the AC-AC adapter effects the sampling of the AC waveform. A separate 5V USB power supply or batteries must be used to power the emonTx. There is an ongoing thread on the forums discussing how this problem might be overcome.

C. CT sensor connections

`General note regarding the installation of CT sensors: the clip-on CT current sensors must be clipped round either the live (brown in the UK), or neutral (blue in the UK) wire. Not both. It is sometimes necessary to carefully remove plastic ducting to access the live an neutral wires. Live terminals should not be exposed but if in doubt switch off the power before investigating. A shock from AC mains electricity can be fatal, if in doubt consult the advice of an experienced electrician.

The CT sensors should be connected to the emonTx before being clipped round a live cable.


Above: CT installation on the live wire AC output from the solar PV inverter. Generation meter can be seen on the top right

D. Powering the emonTx

The emonTx can be powered from 2 x AA batteries or via mini-usb. A 5V USB adapter (commonly available as mobile phone chargers, see this blog post before choosing an adapter). The power adapters we sell through the shop have been tried and tested with the emonTx and emonBase. The emonTx CT_123_voltage example is the correct example to use when using an AC-AC adapter. If your using a emonGLCD use channel 1 on the emontx for consumption and channel 2 for generation.

E. Solar Display

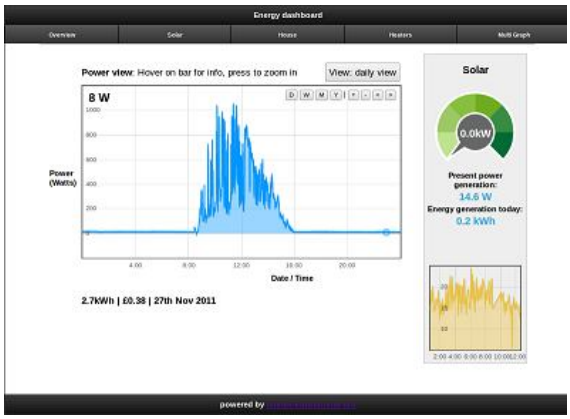
You may like to add a solar energy display to your setup and there is solar pv monitor specific firmware that can be used for this. Once you have installed the Arduino IDE, libraries and firmware following the setting up the adruino type. The solar pv monitor firmware for the display can be selected by going to:

"File > Sketchbook > OpenEnergyMonitor > EmonGLCD > EmonGLCD_SolarPV"The emonGLCD was wall mounted in the living room. The purpose of the emonGLCD is to give the home owner an instant reading of house energy usage compared to the solar PV generation.

consumption at times when a low amount of power is being generated and perform non-essential tasks that consume more power such as washing machine, dishwasher etc. when excess power is being generated. To give the home owner a clear indication of excess power being generated the tri-colour LED's on the top of the emonGLCD are green when power is being exported (excess power being generated) and red when power is being imported (power deficit It has been suggested that a home owner might attempt to reduce their). Financial benefits aside, it was found that the home owner felt personal satisfaction by keeping the lights green when at all possible. Behavioral change due to domestic solar PV monitoring is an interesting topic, there have been several research papers written on the topic, the papers highlight the importance of monitoring and clear indication of both generation and consumption to prompt changes in behavior. The monitoring system described here gives far superior user indication to those used in the research below

F. Emoncms

Example of the kind of dashboard that can be created in emoncms to explore solar pv production. See emoncms user guide on how to use emoncms. Emoncms is a powerful open-source web-app developed as part of this project for processing, logging and visualising energy, temperature and other environmental data.



IV. GOALS AND BENEFITS

Throughout the numerous M&T projects implemented since the 1980s, a certain number of benefits have proved to be recurrent:

A. Energy cost savings: generally 5% of the original energy expenses, according to the carbon trust. Carbon Trust has conducted a study over 1000 small buisness and has concluded that on average an organisation could save 5%
B. Reduction in GHG emissions: lower energy consumption helps reduce emissions
C. Financing: measured energy reductions help obtain grants for energy efficiency projects
D. Improved product and service costing: sub-metering allows the division of the energy bill between the different processes of an industry, and can be calculated as a production cost.

V. CONCLUSION

A flexible, easy-to-use, networked EMS is an important tool for the implementation and monitoring of energy conservation measures. Through its direct digital control capabilities, the EMS provides occupants of a facility with a comfortable, precisely-controlled environment.

The energy-saving opportunities available through a EMS help address the needs for energy and environmental improvements—improvements that are clearly demanded by government organizations and the public alike. The features of TAC's BEMS demonstrate our commitment to remain at the forefront of technical innovation and to provide the "best of breed" BEMS systems and tools to maximize the energy savings capabilities of our customers systems.

It's not just about saving energy in buildings - the term "energy management" is also used in other fields: It's something that energy suppliers (or utility companies) do to ensure that their power stations and renewable energy sources generate enough energy to meet demand (the amount of energy that their customers need). It's used to refer to techniques for managing and

controlling one's own levels of personal energy. We're far from qualified to say anything more about this!

It also has relevance in aviation – it's a skill that aircraft pilots learn in some shape or form. We know nothing about aircraft energy management, but we can at least manage a picture of a man on a plane...

Anyway, from now on we will pay no more attention to these other definitions - all further references to "energy management" will be to the energy-saving sort described above.Whilst energy management has been popular in larger buildings for a long time, it has only recently started catching on in homes. Most homeowners aren't even aware of the term, and take more of a haphazard, flying-blind approach to reducing their energy consumption...

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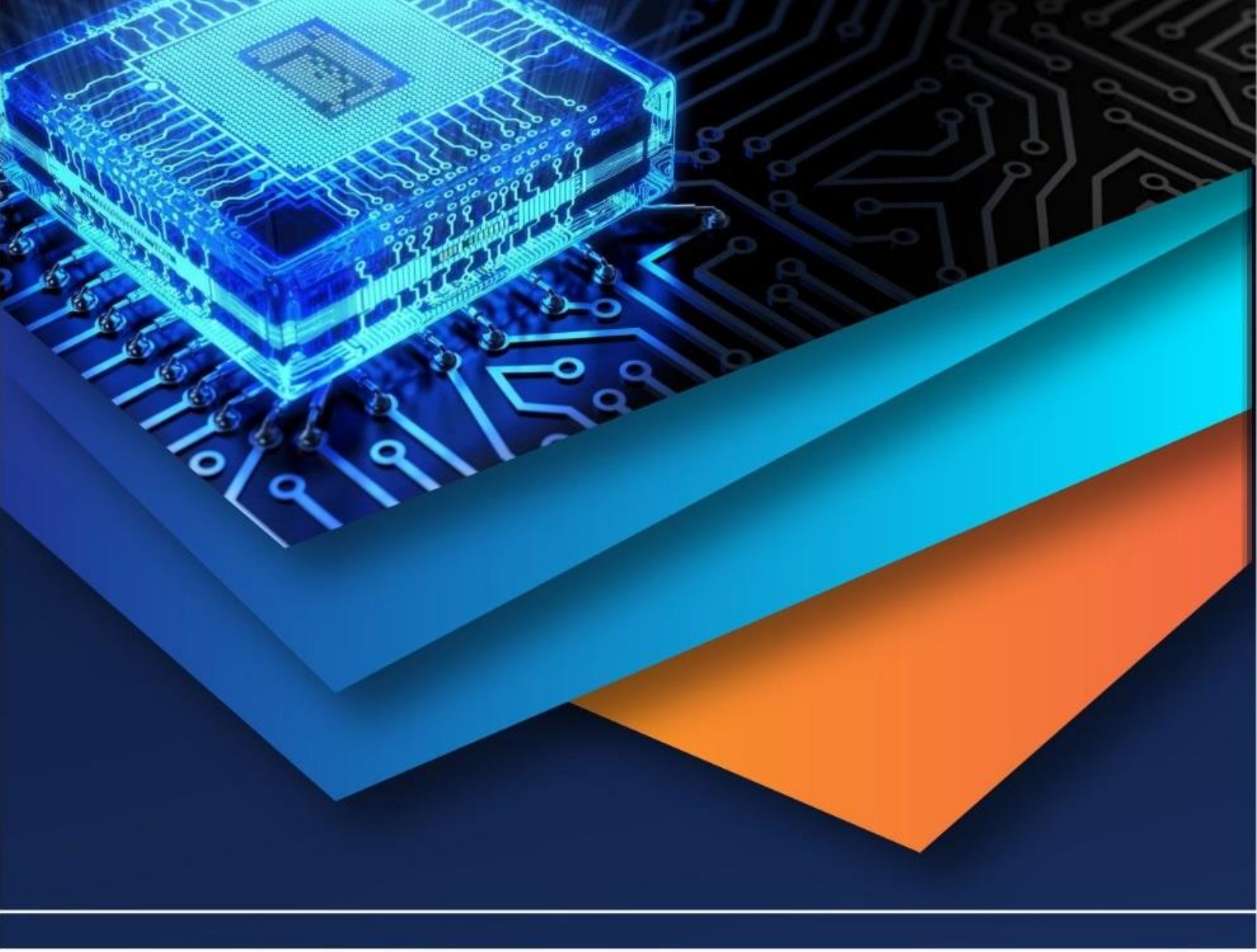

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