oBeMS - open source Building energy Management System

T4 Sustainability Ltd

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AMR and BMS
What are the problems ?

- Cost - hardware, rental or purchase, and software licenses, upgrades etc.
- Lack of open standards.
- Poor interoperability between product ranges and manufacturers.
- Finite product lifecycles and obsolescence.
- Obscure cabling / networking requirements.

What have we set out to do ?

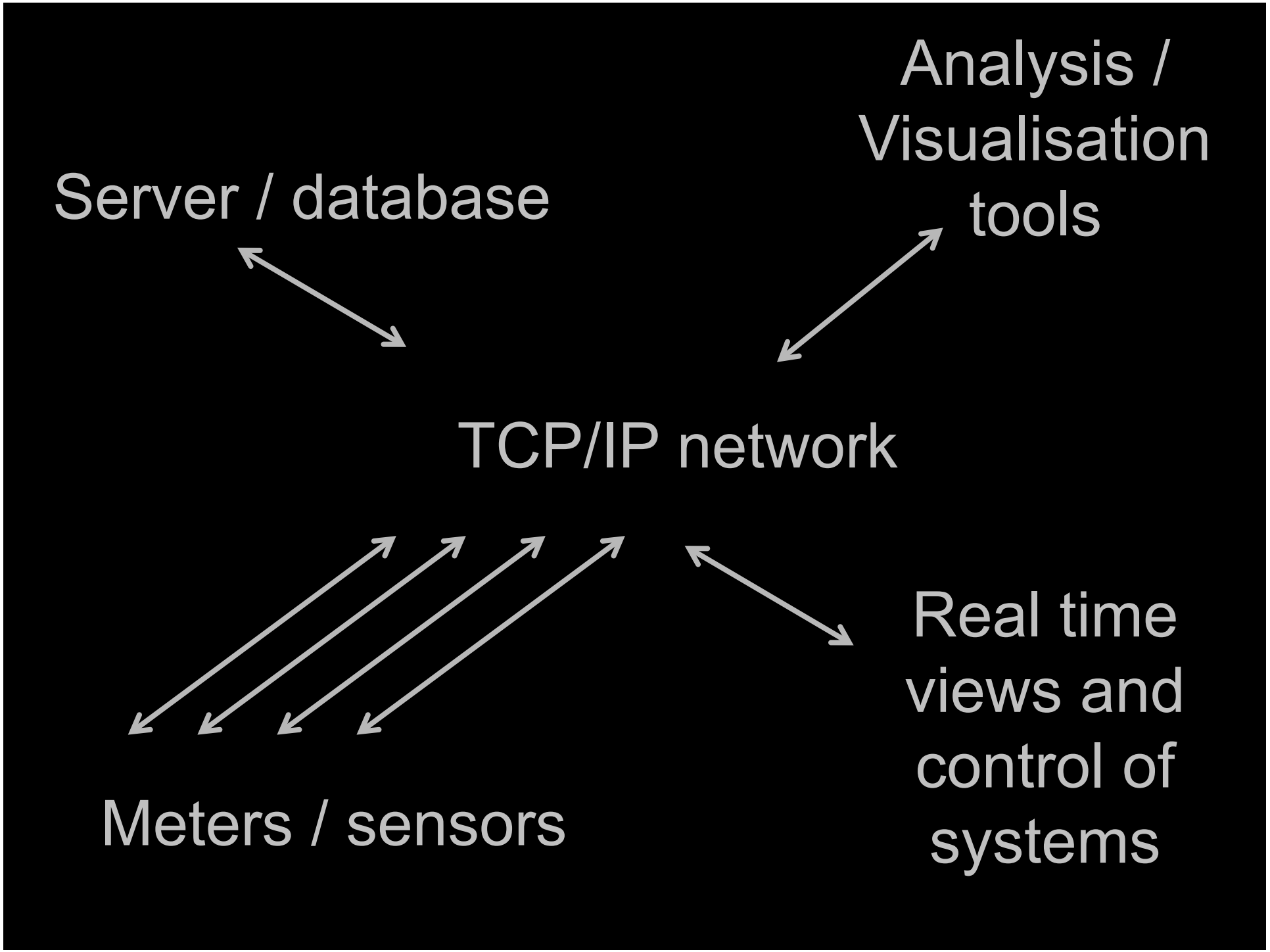
- Long range plan is to develop ‘oBeMS’, an Open Source Building Energy Management System.
- Some AMR functionality is already prototyped as a useful subset of the BMS system.

- BMS functionality to be developed to support users of buildings, and academic research (e.g. the SmartPod project, undertaken by Derby University, EKV Design, De Montfort University, and T4 Sustainability).

- Some basic control experiments have already started.

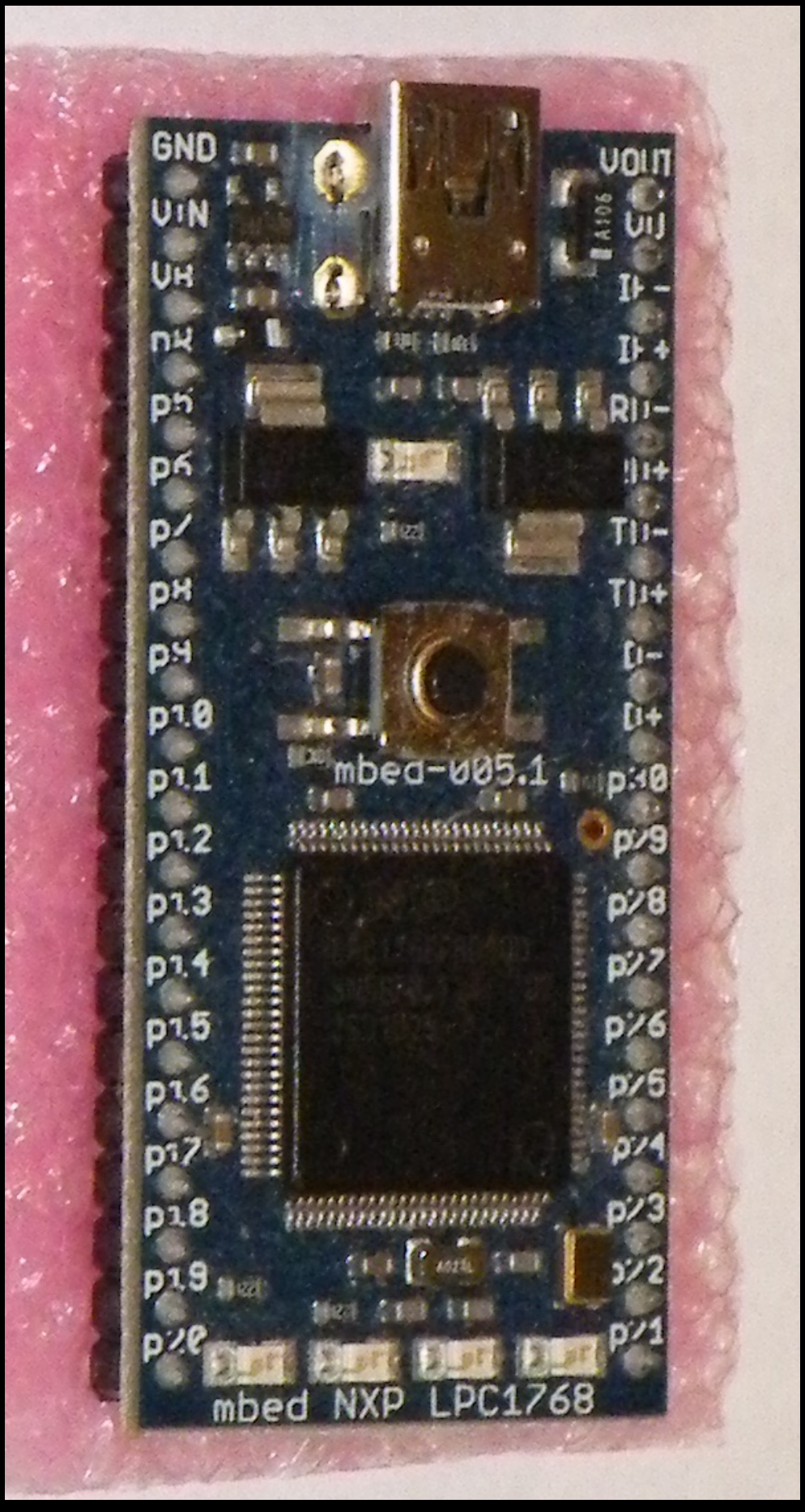
What do we want from the system ?

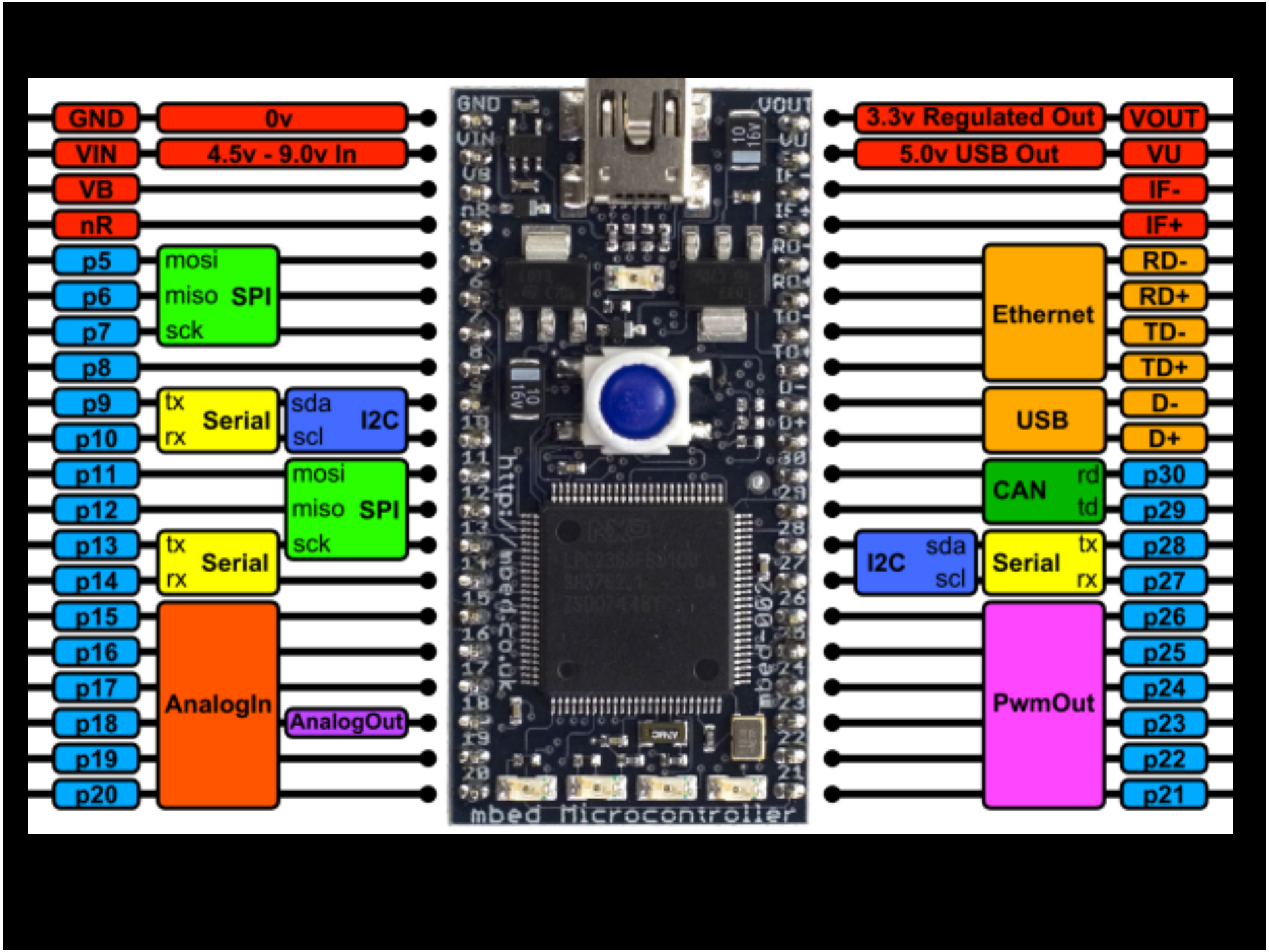
- Modular, hardware independent.
- Based on widely available open source software libraries.
- Single location or distributed (IoT).
- Low cost but accurate, flexible & configurable.
- Data structures to support analysis and decision making from time series data.
- Open Source product.

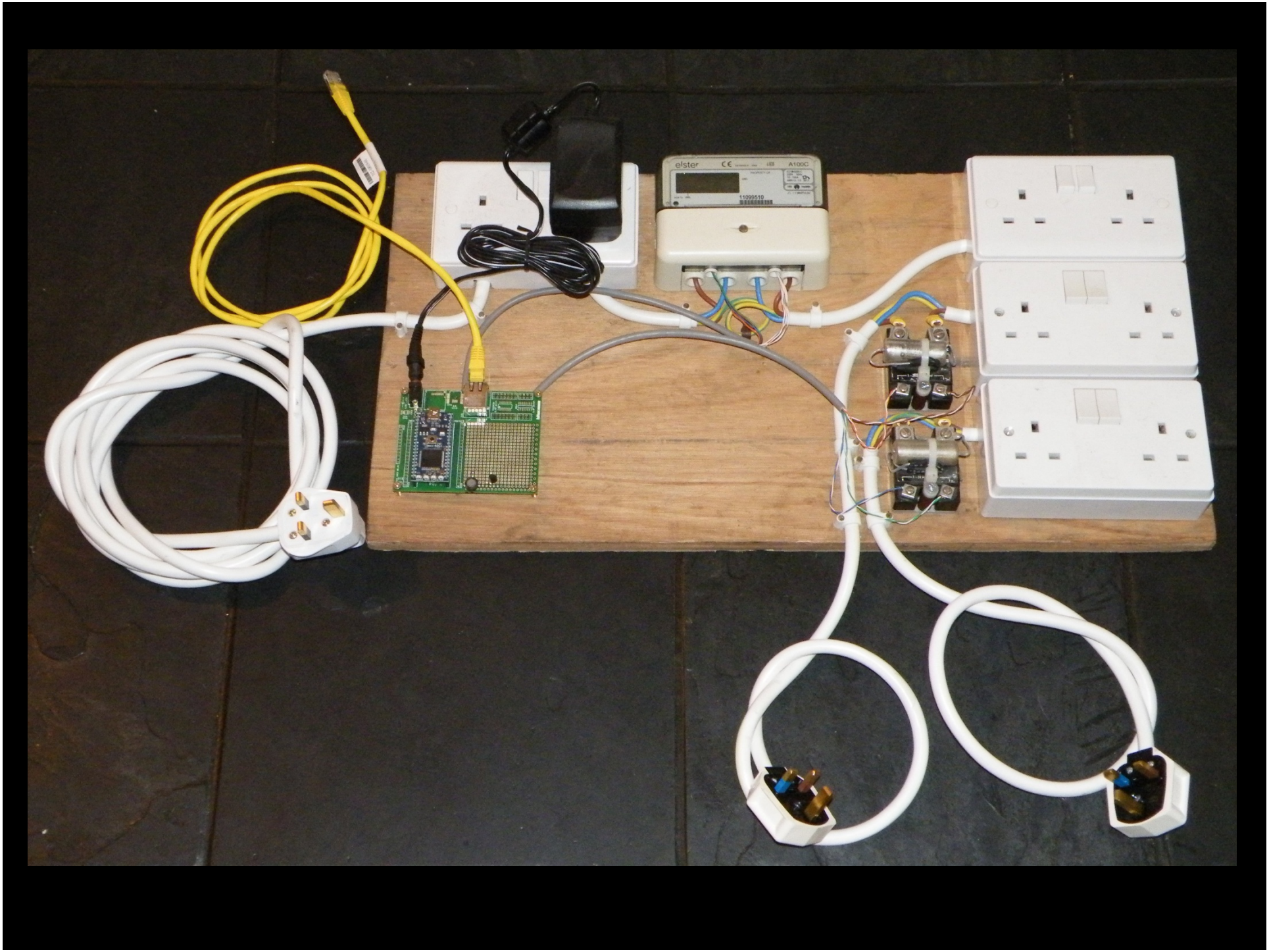

Server / database
Analysis / Visualisation tools
TCP/IP network
Meters / sensors
Real time views and control of systems

What hardware are we using ?

- First try:
- Sensors (and actuators) have been implemented using the 40 pin MBED device which offers many useful features.
- See http://mbed.org


GND
VIN
mbed-005.1
mbed NXP LPC1768


GND
0v
VIN
4.5v - 9.0v In
VB
nR
p5
p6
p7
mosi
miso
SPI
sck
p8
p9
p10
tx
rx
Serial
sda
scl
I2C
p11
p12
mosi
miso
SPI
sck
p13
p14
tx
rx
Serial
p15
p16
p17
p18
p19
p20
AnalogIn
AnalogOut
GND
VIN
VB
nR
VOUT
VU
IF-
IF+
RD-
RD+
TD-
TD+
D-
D+
http://mbed.co.uk
mbed Microcontroller
3.3v Regulated Out
5.0v USB Out
VOUT
VU
IF-
IF+
Ethernet
RD-
RD+
TD-
TD+
USB
D-
D+
CAN
rd
td
p30
p29
I2C
sda
scl
Serial
tx
rx
p28
p27
PwmOut
p26
p25
p24
p23
p22
p21


elster
A100C
11099510

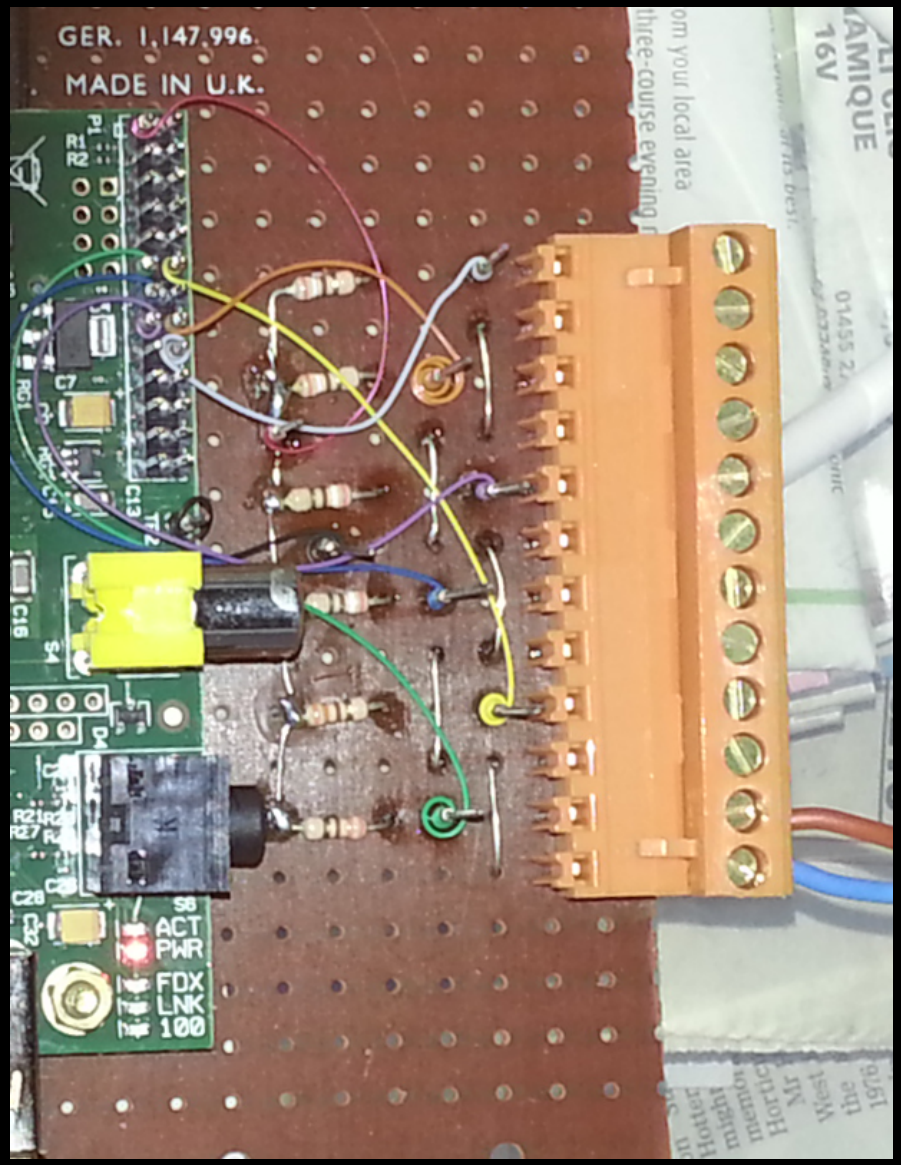
- Second try:
- Raspberry Pi - Cheaper, far more memory, open source OS and tool chains.
- See http://www.raspberrypi.org
- Could just as soon be BeagleBone etc…

- Quite low power (3.5 Watts).
- 17 or more programmable GPIO digital IO pins that can be configured to trigger interrupts.
- Built in 100MHz Ethernet with socket.
- USB sockets for more disk or wireless LAN.

Simple system - basic PV monitoring


CIRCUIT DIAGRAM FOR 2.5kW/6
PHOTOVOLTAIC INSTALLATION AT 98


VEROBOARD
PART NO 47/1001
MADE IN U.K.
Made in China
MORSUN

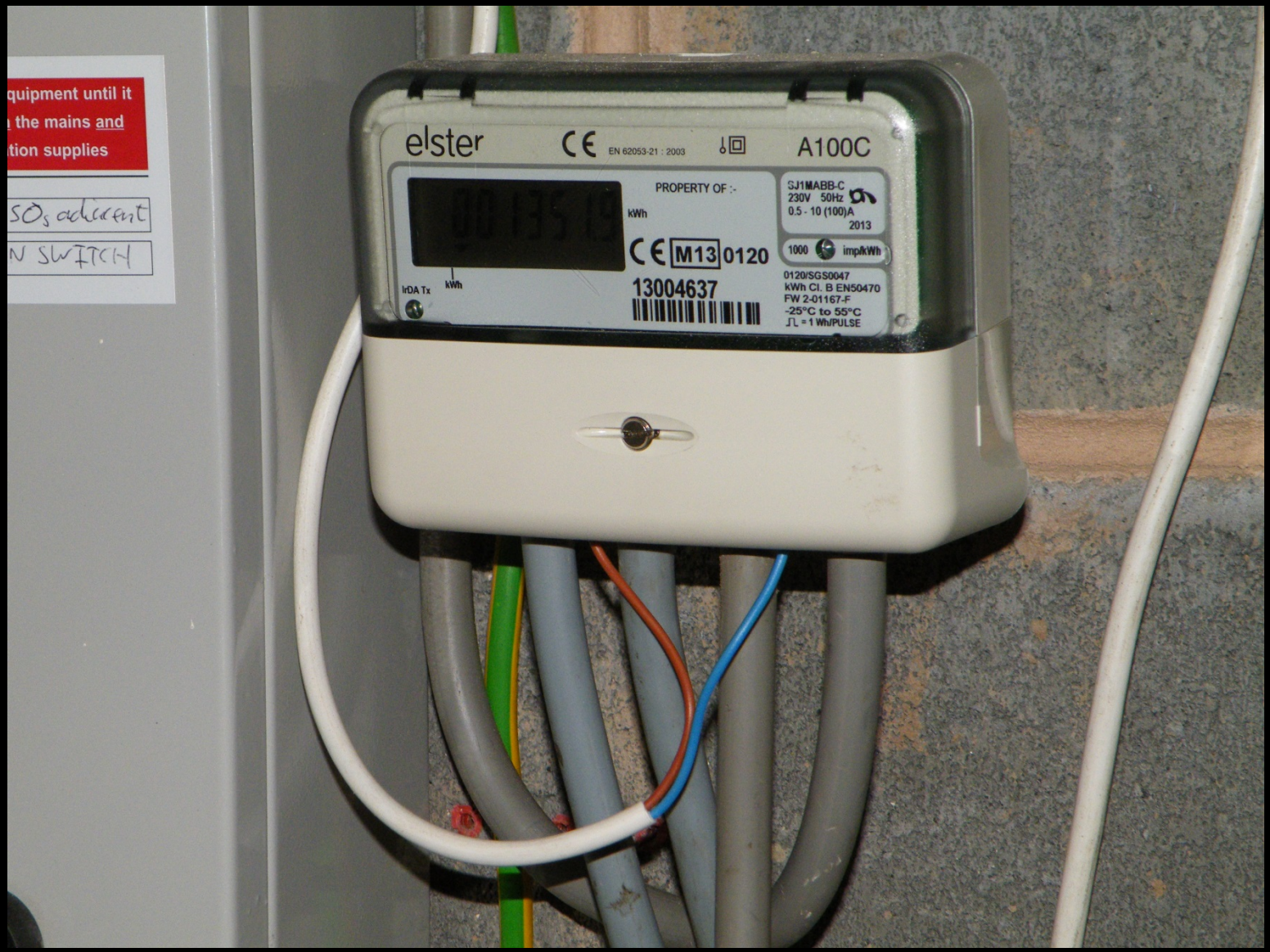


390Ω pull up resistors (now using 120Ω) to the 3.3V rail.

Not the 5V rail !

More complex - 2 PV + elec consumption


Danger
A3
CAUTION
Solar PV on roof
Solar PV on roof


quipment until it
the mains and
tion supplies
SOs adjacent
N SWITCH
elster
EN 62053-21 : 2003
A100C
PROPERTY OF :-
kWh
SJ1MABB-C
230V 50Hz
0.5 - 10 (100)A
2013
1000 imp/kWh
M13 0120
IrDA Tx
kWh
13004637
0120/SGS0047
kWh Cl. B EN50470
FW 2-01167-F
-25°C to 55°C
= 1 Wh/PULSE

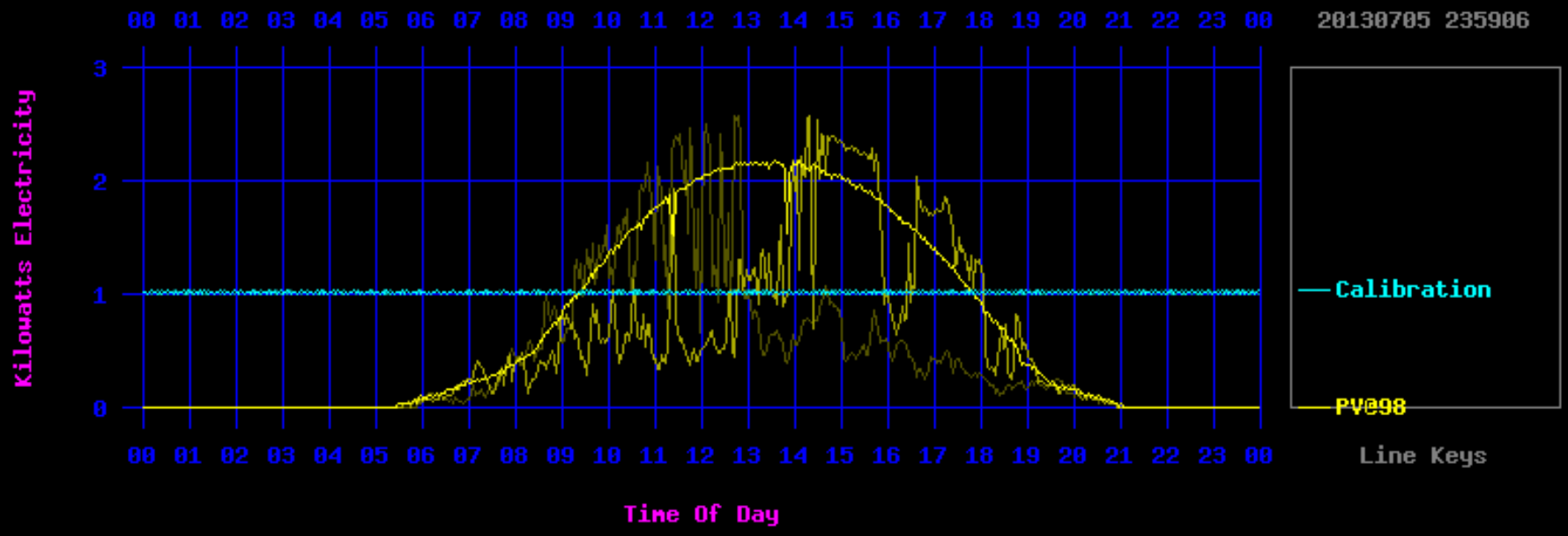

PROTEUS
Danger


PROTEUS

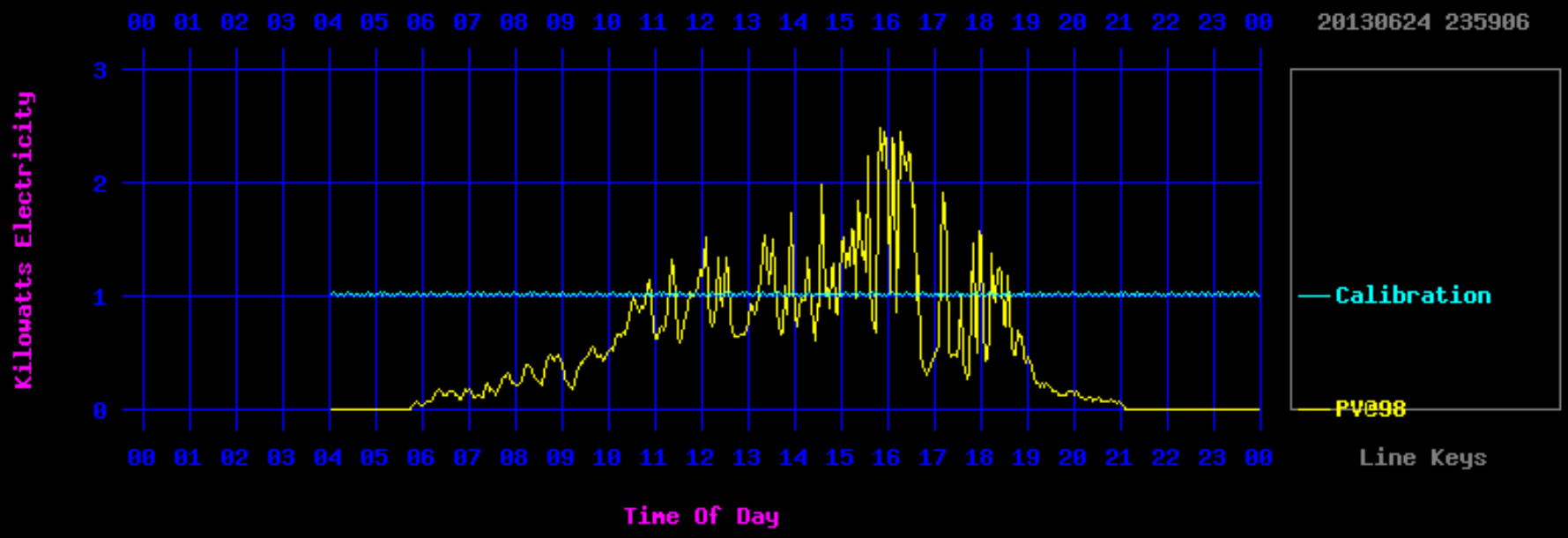
Safety

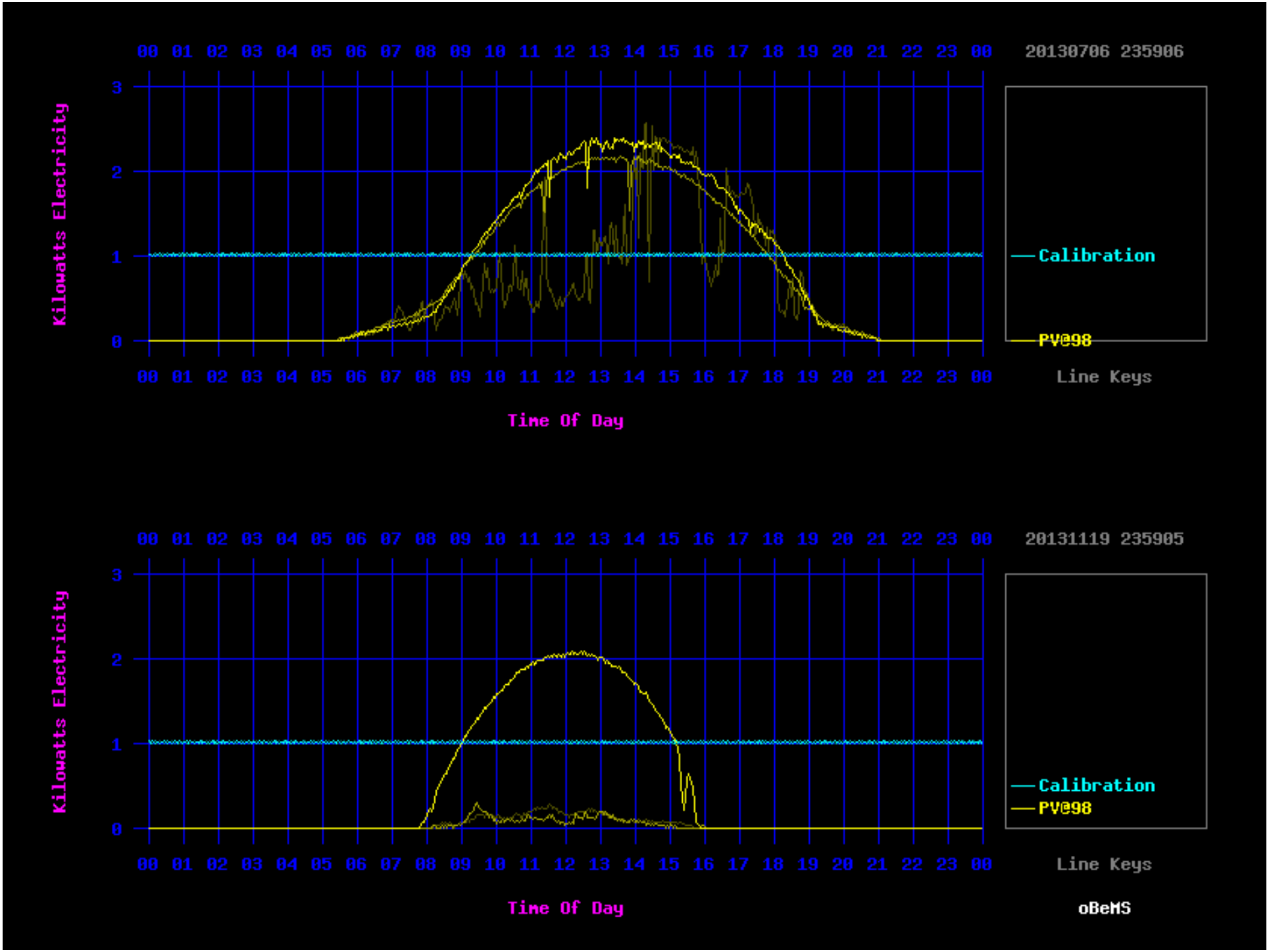
- Medical grade PSU (available from RS)
- Magnetic (transformer coupled) isolation of 100BASE-TX Ethernet, or radio 802.11g/n
- 12kV of isolation from Elster A100C
- Plastic case
- Nylon insulating mounts for the board
- Follow 17th Edition Wiring Regulations
- Use accredited electrician to install

What sort of data can be collected ?



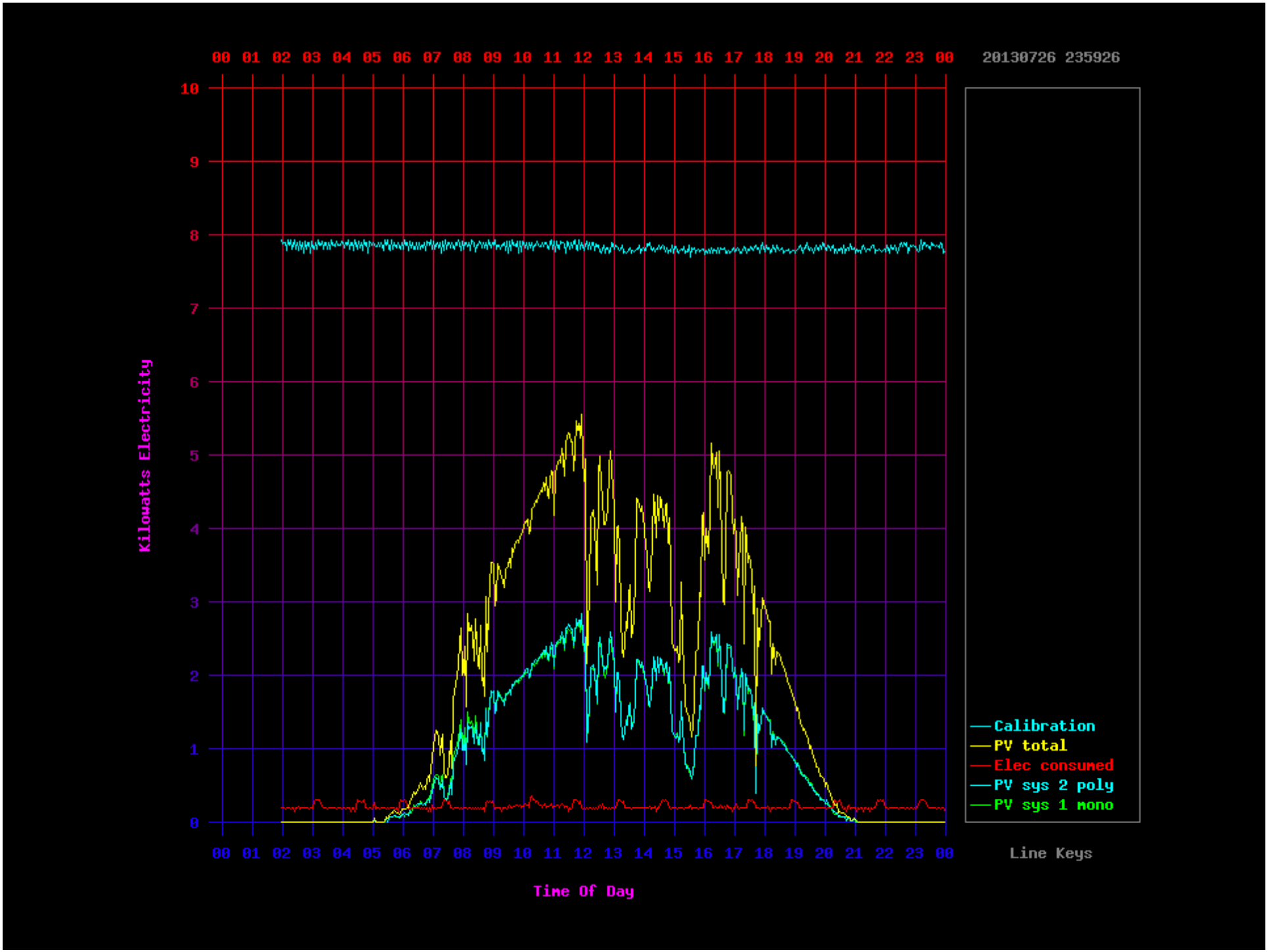
Simple PV system - Jun to Nov

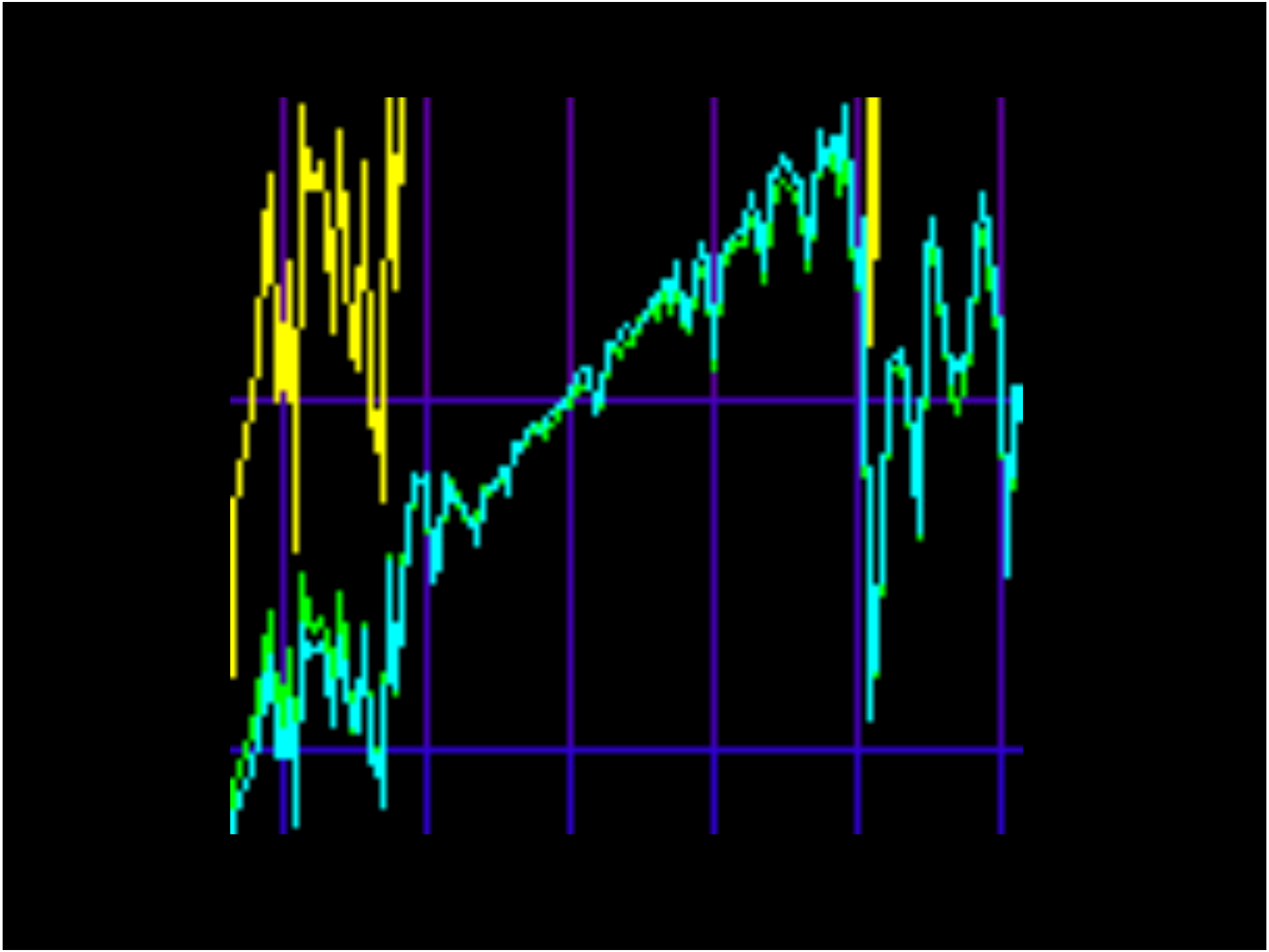


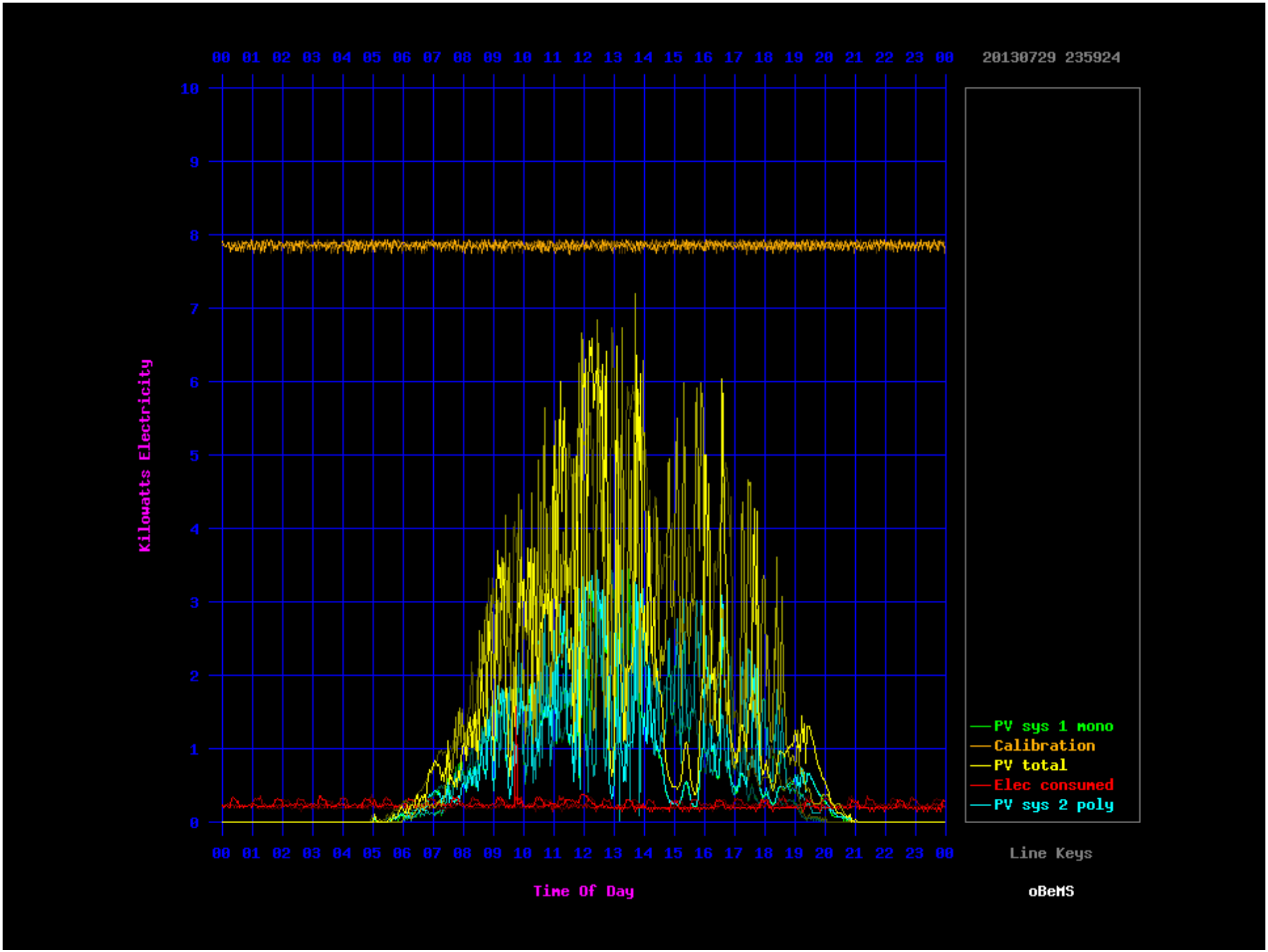

00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
20130706 235906
Kilowatts Electricity
3
2
1
0
Calibration
PV@98
Line Keys
Time Of Day
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
20131119 235905
Kilowatts Electricity
3
2
1
0
Calibration
PV@98
Line Keys
Time Of Day
oBeMS

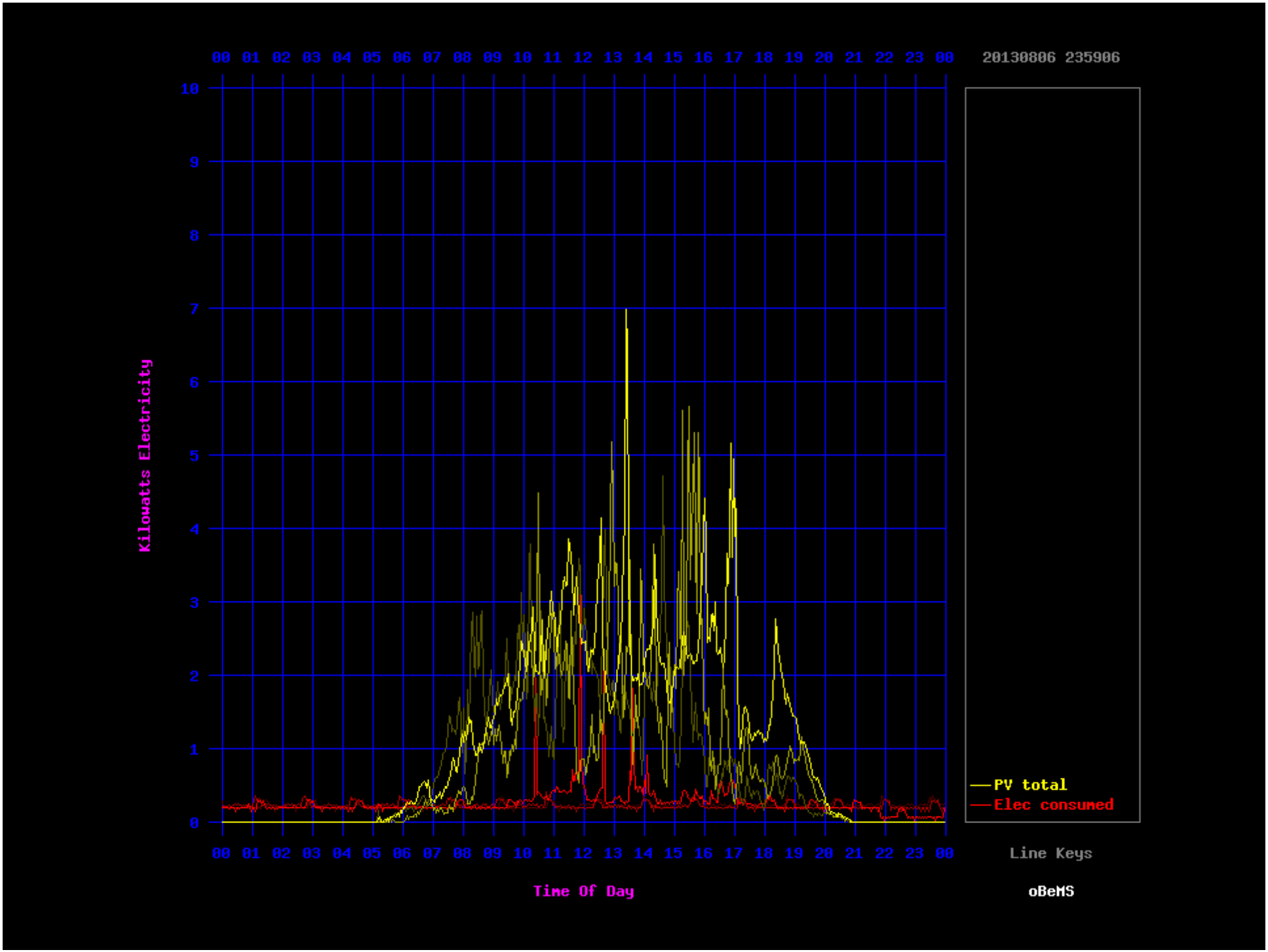
More complex site –

Two PV systems +
electricity consumption


00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
20130726 235926
10
9
8
7
6
5
4
3
2
1
0
Kilowatts Electricity
Calibration
PV total
Elec consumed
PV sys 2 poly
PV sys 1 mono
Line Keys
Time Of Day




00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
20130729 235924
10
9
8
7
6
5
4
3
2
1
0
Kilowatts Electricity
PV sys 1 mono
Calibration
PV total
Elec consumed
PV sys 2 poly
Line Keys
Time Of Day
oBeMS


00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
20130806 235906
10
9
8
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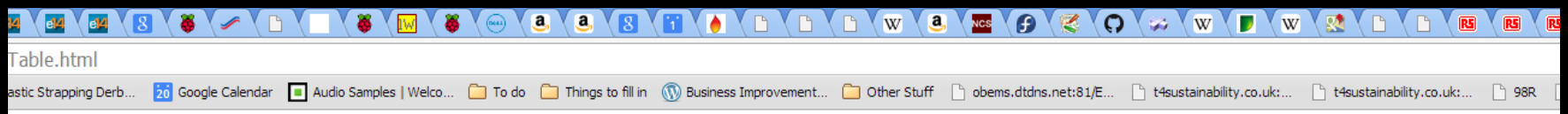
6
5
4
3
2
1
0
Kilowatts Electricity
PV total
Elec consumed
Line Keys
Time Of Day
oBeMS



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oBeMS - Live Energy Measurement

Report at 20131201 232540	*Total kWh Generated*	*kWh Consumed*	*Net Export kWh*	*Calibration kWh*	*Part Of Day*
Sun 20131201	7.773	4.350	3.423	183.062	1406 minutes, 97.639%
Sat 20131130	7.255	4.477	2.778	187.611	1440 minutes, 100.000%
20131129	2.281	4.449	-2.168	187.641	1440 minutes, 100.000%
20131128	3.686	5.397	-1.711	187.560	1440 minutes, 100.000%
Wed 20131127	7.823	4.899	2.924	187.577	1440 minutes, 100.000%
20131126	4.475	4.428	0.047	177.005	1440 minutes, 100.000%
20131125	5.553	5.897	-0.344	184.011	1440 minutes, 100.000%
Sun 20131124	4.176	4.506	-0.330	187.653	1440 minutes, 100.000%
Sat 20131123	4.281	4.491	-0.210	187.729	1440 minutes, 100.000%
20131122	9.020	5.907	3.113	187.936	1440 minutes, 100.000%
20131121	7.351	5.558	1.793	188.017	1440 minutes, 100.000%
Wed 20131120	6.791	8.907	-2.116	188.134	1440 minutes, 100.000%
20131119	1.054	1.999	-0.945	75.542	778 minutes, 54.028%

oBeMS, open source Building energy Management System,
on Raspberry Pi hardware - T4 Sustainability Limited.

Minimal and maximal systems

- Simplest - one location, one sensor, one Pi.

- Maximal - many locations, many sensors at each location, archival database, visualisation and analytical tools. Can aggregate or compare data from multiple sites with single SQL query.

What's the communications architecture?

- Client server communicating via IP address and port number for now.
- Modules can be distributed to run anywhere, (but should be clustered on hardware to optimise fault tolerance, and minimise network delays).

What internal data structures are used ?

- The system is designed to facilitate decision making by BMS components, so data has to be available to track recent trends, allow the analysis of previous decisions and their consequences, and to allow historic conditions and energy use to be reviewed.
- A series of 'snapshot' data structures are used to store time series data and support reporting and decision making.

What messaging protocol are we using ?

- Various XML message types have been considered, but are not yet in use.
- The very simple ad hoc protocols used now are very simple to read and interpret.
- Other message protocols could easily be added as modules.

What modules have we got so far ?

- ObemsGertServer (analog inputs e.g. for temperature measurement)
- Obems1wbServer (1 wire bus interface to DS18B20)
- ObemsPulseServer (detection of pulses from electricity, water, gas meters, GM sets etc)
- ObemsPulseGenerator (generates pulses for calibration etc)
- ObemsClientTemplate (template for reporting current state, BMS decision making, and archiving state and decisions)
- ObemsDbServer (Interface to SQL database)
- ObemsCgiDbViewer (CGI database web viewer)
- ObemsCsvDbDumper (.csv files from database)

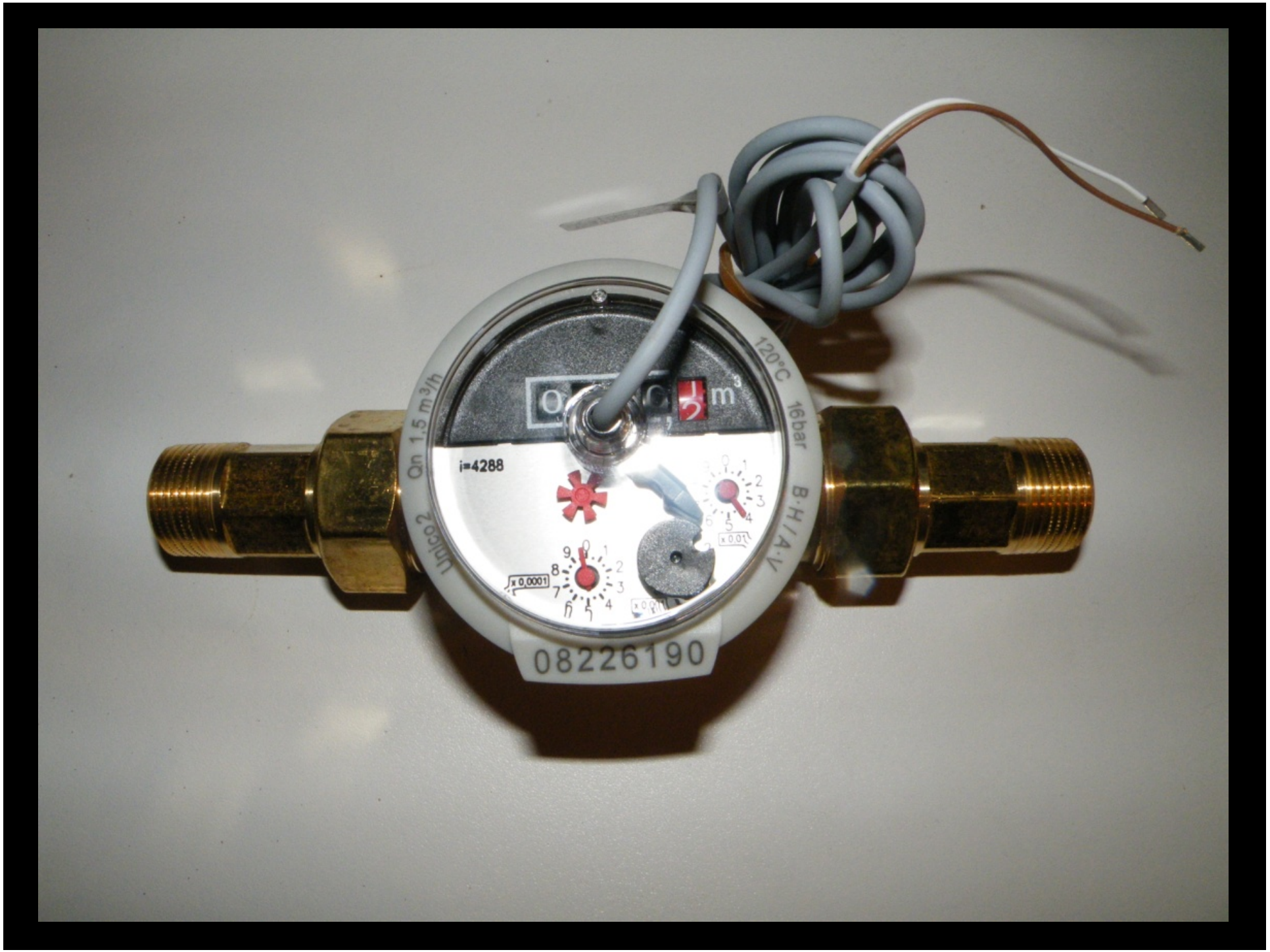
What can be monitored ?

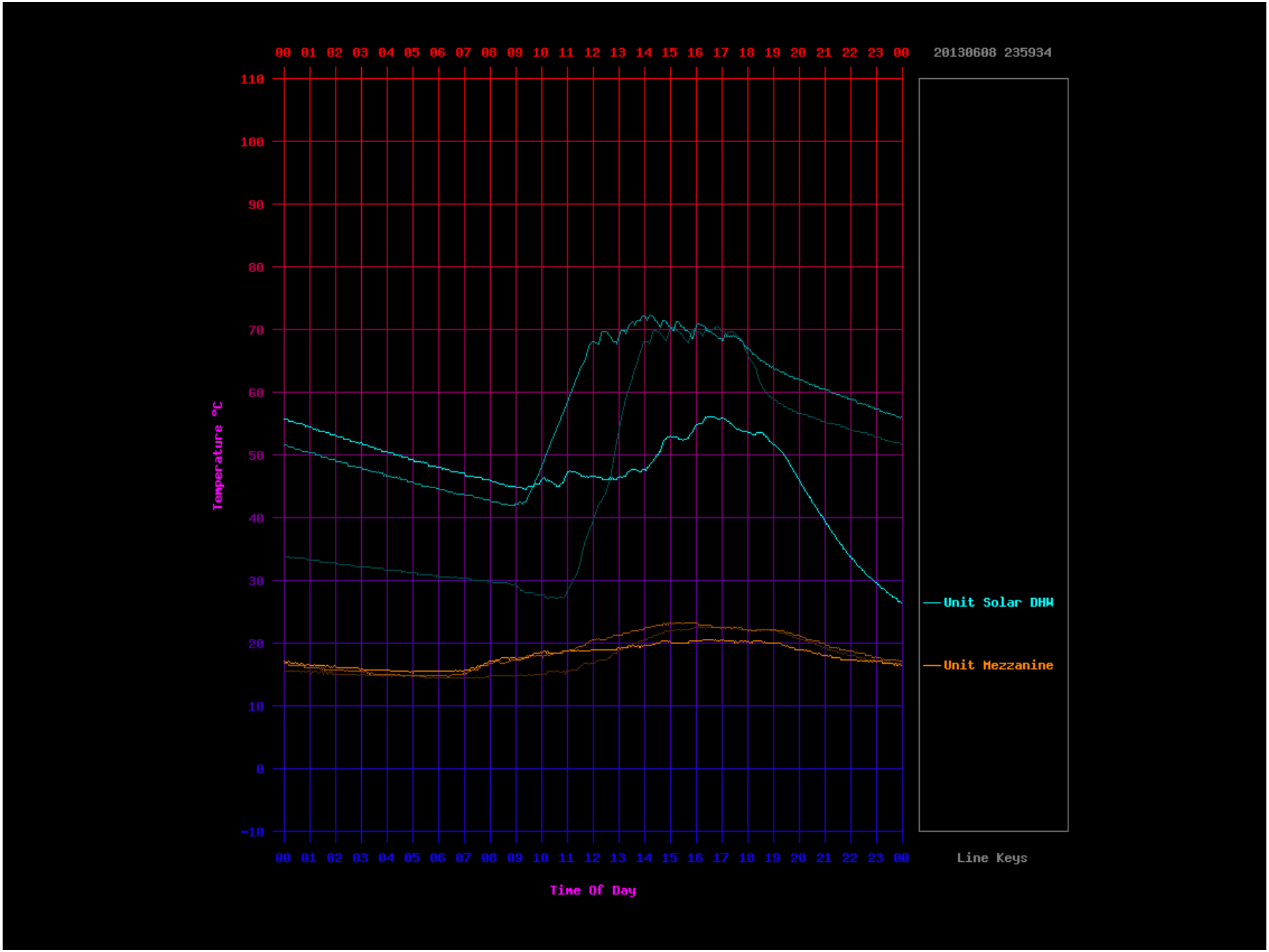
Anything with a pulse output

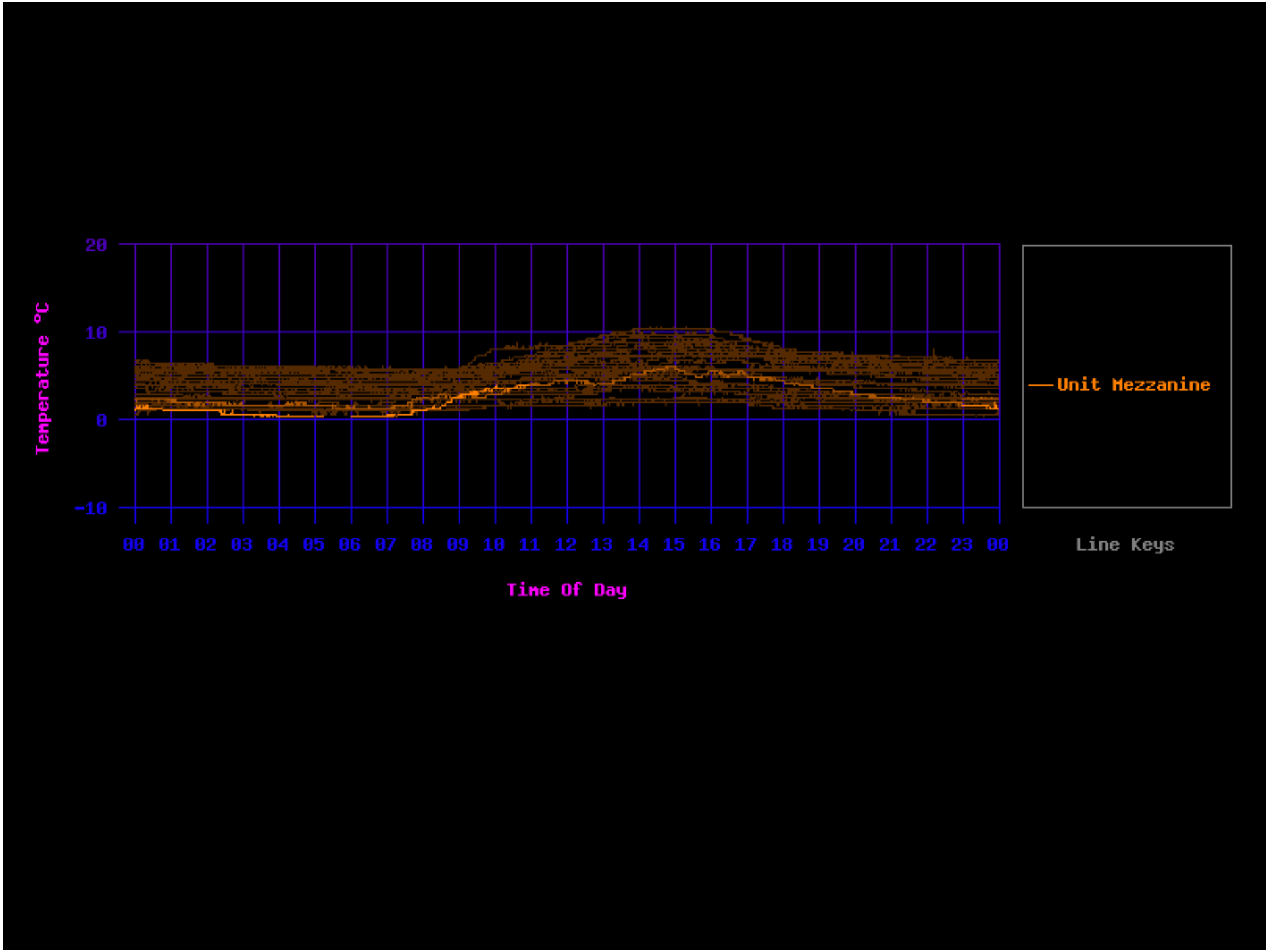
- electricity meters,
- gas meters,
- water meters,
- GM counters etc.

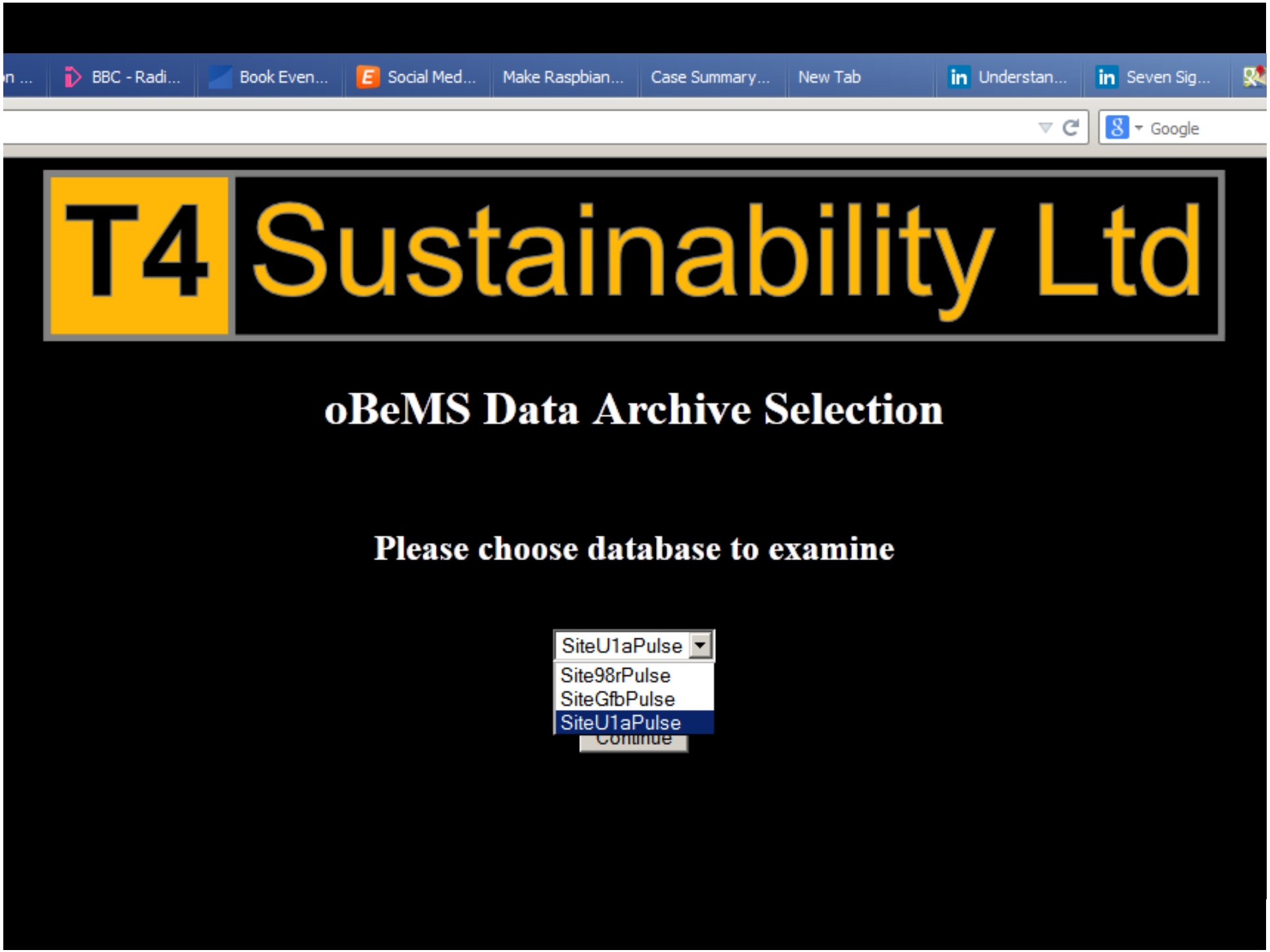
Analogue signals

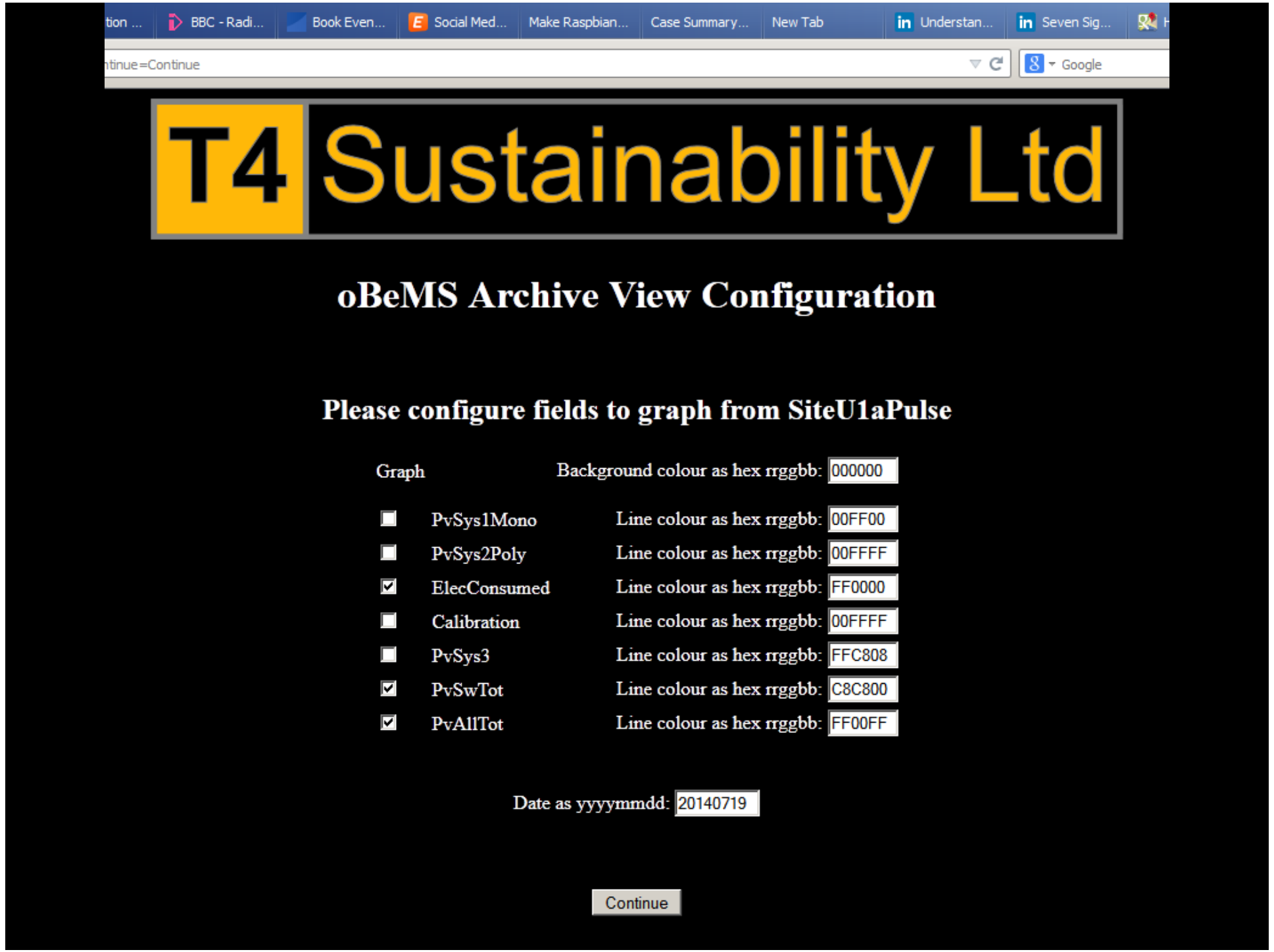
- anything that can be converted to a voltage

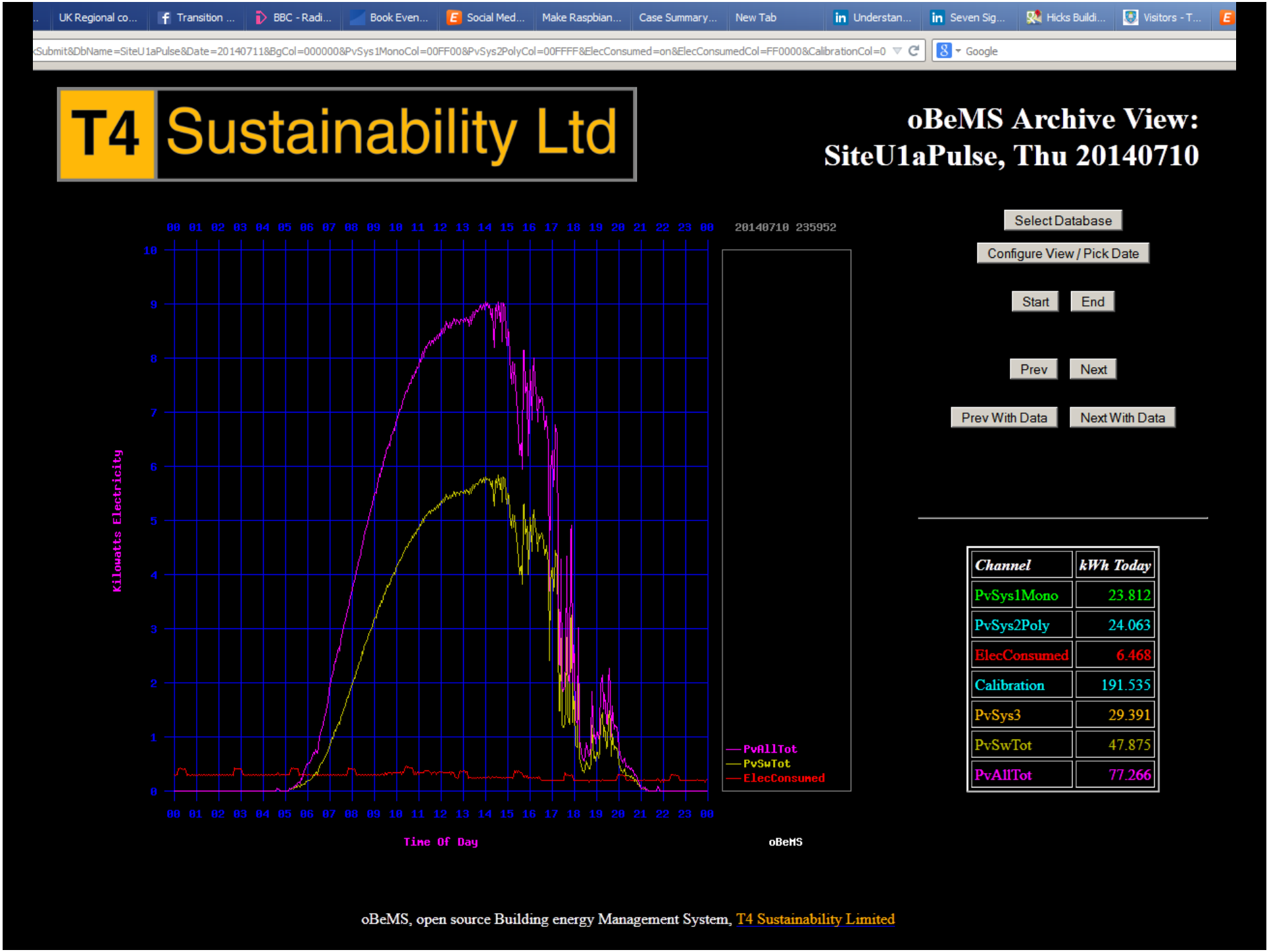

Unico2
Qn 1,5 m³/h
120°C
16bar
B·H/A·V
i=4288
x 0,0001
x 0,01
08226190


00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
20130608 235934
110
100
90
80
70
60
50
40
30
20
10
0
-10
Temperature °C
Unit Solar DHW
Unit Mezzanine
Line Keys
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
Time Of Day


20
10
0
-10
Temperature °C
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
Time Of Day
Unit Mezzanine
Line Keys


BBC - Radi...
Book Even...
Social Med...
Make Raspbian...
Case Summary...
New Tab
Understan...
Seven Sig...
Google
T4 Sustainability Ltd
oBeMS Data Archive Selection
Please choose database to examine
SiteU1aPulse
Site98rPulse
SiteGfbPulse
SiteU1aPulse
Continue


tion ...
BBC - Radi...
Book Even...
Social Med...
Make Raspbian...
Case Summary...
New Tab
Understan...
Seven Sig...
ntinue=Continue
Google
T4 Sustainability Ltd
oBeMS Archive View Configuration
Please configure fields to graph from SiteU1aPulse
Graph
Background colour as hex rrggbb: 000000
PvSys1Mono
Line colour as hex rrggbb: 00FF00
PvSys2Poly
Line colour as hex rrggbb: 00FFFF
ElecConsumed
Line colour as hex rrggbb: FF0000
Calibration
Line colour as hex rrggbb: 00FFFF
PvSys3
Line colour as hex rrggbb: FFC808
PvSwTot
Line colour as hex rrggbb: C8C800
PvAllTot
Line colour as hex rrggbb: FF00FF
Date as yyyymmdd: 20140719
Continue


UK Regional co...
Transition ...
BBC - Radi...
Book Even...
Social Med...
Make Raspbian...
Case Summary...
New Tab
Understan...
Seven Sig...
Hicks Buildi...
Visitors - T...
Submit&DbName=SiteU1aPulse&Date=20140711&BgCol=000000&PvSys1MonoCol=00FF00&PvSys2PolyCol=00FFFF&ElecConsumed=on&ElecConsumedCol=FF0000&CalibrationCol=0
Google
T4 Sustainability Ltd
oBeMS Archive View:
SiteU1aPulse, Thu 20140710
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
20140710 235952
10
9
8
7
6
5
4
3
2
1
0
Kilowatts Electricity
PvAllTot
PvSwTot
ElecConsumed
Time Of Day
oBeMS
Select Database
Configure View / Pick Date
Start
End
Prev
Next
Prev With Data
Next With Data
Channel
kWh Today
PvSys1Mono
23.812
PvSys2Poly
24.063
ElecConsumed
6.468
Calibration
191.535
PvSys3
29.391
PvSwTot
47.875
PvAllTot
77.266
oBeMS, open source Building energy Management System, T4 Sustainability Limited

UK Regional co... | Transition ... | BBC - Radi... | Book Even... | Social Med... | Make Raspbian... | Case Summary... | New Tab | Understan... | Seven Sig... | Hicks Buildi... | Visitors - T...

...Submit&DbName=SiteU1aPulse&Date=20140130&BgCol=000000&PvSys1MonoCol=00FF00&PvSys2PolyCol=00FFFF&ElecConsumed=on&ElecConsumedCol=FF0000&CalibrationCol=0

Google

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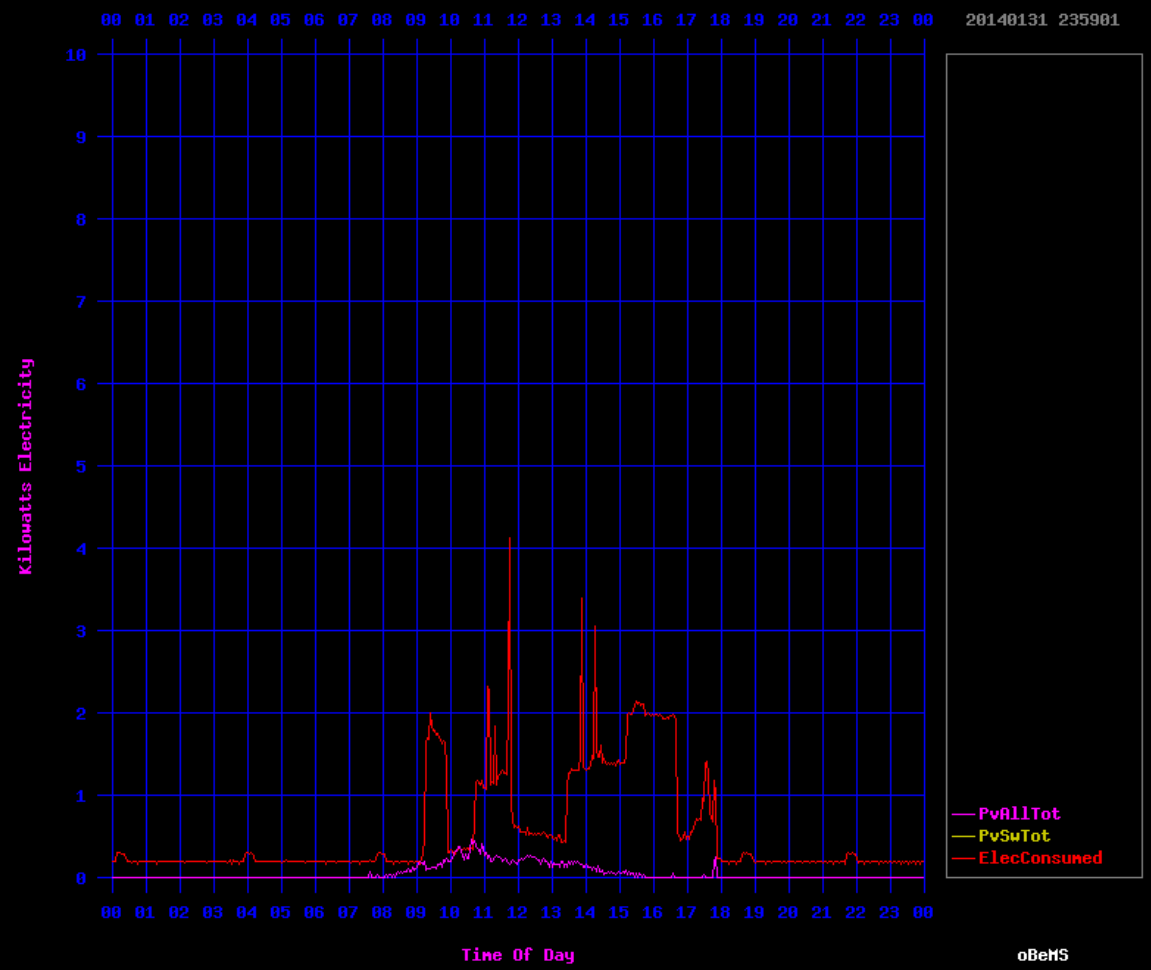
oBeMS Archive View: SiteU1aPulse, Fri 20140131



Select Database

Configure View / Pick Date

Start End

Prev Next

Prev With Data Next With Data

Channel	*kWh Today*
PvSys1Mono	0.570
PvSys2Poly	0.613
ElecConsumed	12.997
Calibration	191.739
PvSys3	0.000
PvSwTot	1.183
PvAllTot	1.183

Future plans for AMR?

- Reliability and stability improvements.
- GUI configuration tools for non programmers.

What sort of features does this system need ?

- Stable - should never crash.
- When it does crash, it should restart at once.
- When it crashes, it shouldn't corrupt file systems or loose data.

- Watchdog timers
- Read only core file system
- More on line tools

- Development of BMS control functions

- Dissemination - **Share and Enjoy !**
- Mailing list / discussion forum / blog.
- Web site, source code and documentation on line.

Which Open Source license ?

- http://www.opensource.org/docs/osd
- Probably GNU General Public License v3
- http://www.gnu.org/

What is Free ?

- “Free software” is a matter of liberty, not price.
- Think of “free” as in “free speech”, not as in “free beer”.

To quote http://www.gnu.org/

- The **freedom** to run the program, for any purpose (freedom 0).
- The **freedom** to study how the program works, and adapt it to your needs (freedom 1). Access to the source code is a precondition for this.

- The **freedom** to redistribute copies so you can help your neighbour (freedom 2).

- The **freedom** to improve the program, and release your improvements to the public, so that the whole community benefits (freedom 3). Access to the source code is a precondition for this.

- For now, oBeMS is primarily an experimental, diagnostic and investigative tool.
- Not to be used to meet statutory requirements.
- To ensure correct readings, it’s easy to check what the system measures against the change of meter reading.

Can systems be adopted on sites using different energy monitoring equipment ?

- Yes, though this will require development.
- Our view is that the interfaces of these tools should be fully documented and free for anyone to use, including the developers of commercial products.
- We hope this will encourage development of open interfaces and standards.

Are there other projects like this ?

We're pleased to say that there are, and we anticipate that more will emerge over time. Examples include:

- http://openenergymonitor.org/emon/
- http://www.gurux.fi/index.php?q=AMIIntroduction
- CAT project under development.

Can I see this running live ?

Yes - please contact for latest test URLs.

Thank you - Any questions?

Contact us:
John@T4sLtd.co.uk
07785 563116

T4 Sustainability Ltd

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