Chris Priest

@cjrpriest

HOW I TURNED MY GAS METER SMART USING MY OWN SOFTWARE, A RASPBERRY PI

(AND SOME OTHER BITS)

* Who am I, who is Amido
    * We are small consultancy (~120 people) based in shoreditch who build green field projects for high profile clients, clients that you will have heard of
    * We are hiring
* What we're going to cover
    * The promise of smart meters, vs the reality that we've realised
    * My non-smart energy meters, in particular my gas meter, the problems
    * The solution I came up with
    * What the industry can learn
    * a critique

@cjrpriest

Smart meters: the promise

AMIDO

@cjrpriest

Smart Meters: The Promise

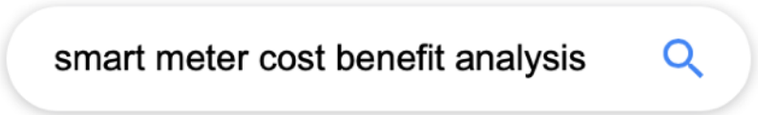
Icons made by Freepik from www.flaticon.com

AMIDO

* Summary
    * Smart meter -> we will reduce energy usage, carbon emissions
    * Suppliers -> more efficient ops from meter reading feed
    * Network ops ->
        * detailed real-time holistic view of national energy consumption
        * better idea of where to place resources & money
        * better national energy management

@cjrpriest

Smart Meters: The Promise



AMIDO

* Energy monitor — see what you are using in pounds & pence — save money & the environment

* Send meter readings automatically / no more estimated bills

* No more intrusive visits

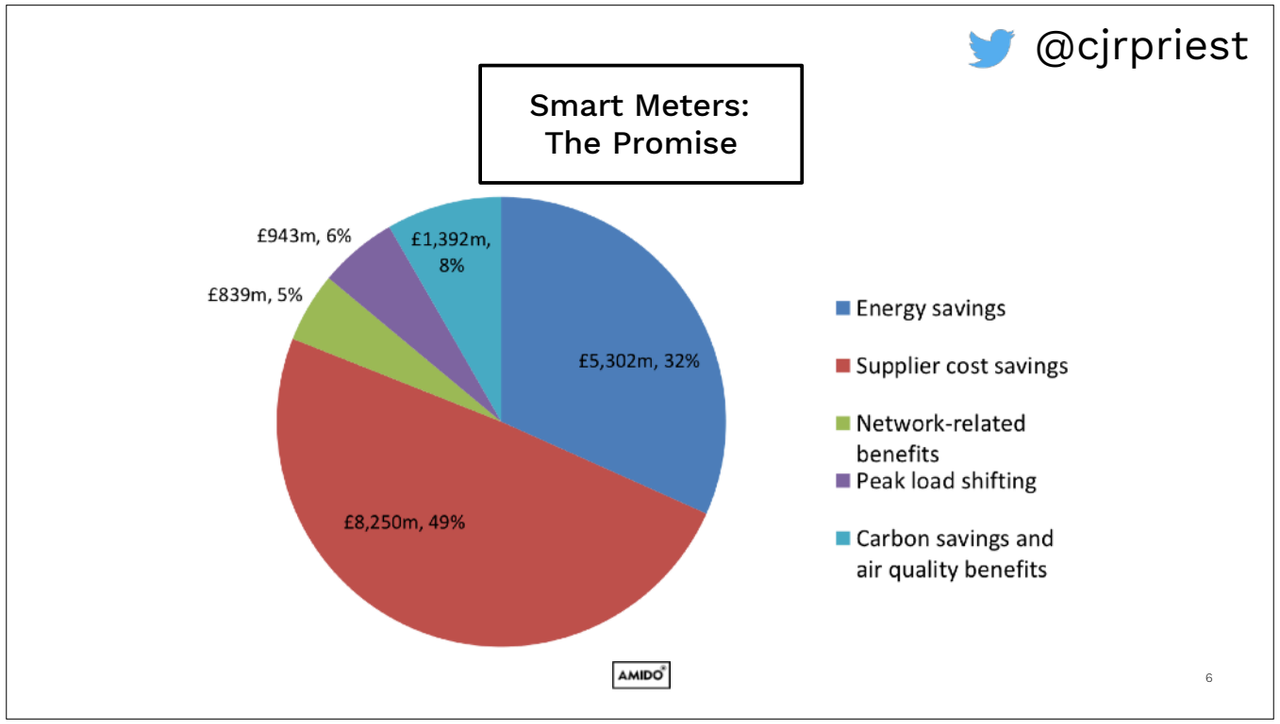
* Upgrade the national energy system —> smart grid, where it's possible to manage energy more efficiently nationally across the network

@cjrpriest

Smart Meters: The Promise

smart meter cost benefit analysis

£14.3 - 16.7bn



* Summary:
    * 40% - Smart monitor —> reduce energy usage, energy efficient behaviour + reduce carbon emissions
    * 49% - Supplier saving
        * less site visits
        * Reduced call centre usage (no estimated bills)
        * Smoother supplier switch — real time meter reading
    * 11% - Network operators (national grid)
        * Outage management
        * Targeted & informed investment decisions
        * Time Of Use tariffs — shift electricity usage to cheaper off-peak times
        * Generation management
        * Potential for future dynamic TOU, domestic Demand Side Response (adjusting usage based-on realtime grid-demand)

@cjrpriest

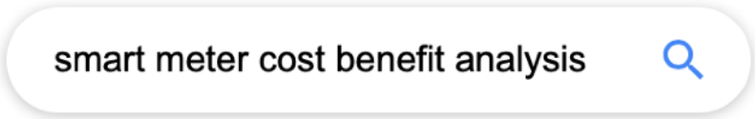
Smart Meters: The Promise

smart meter cost benefit analysis

£14.3 - 16.7bn

@cjrpriest

Smart Meters: The Promise

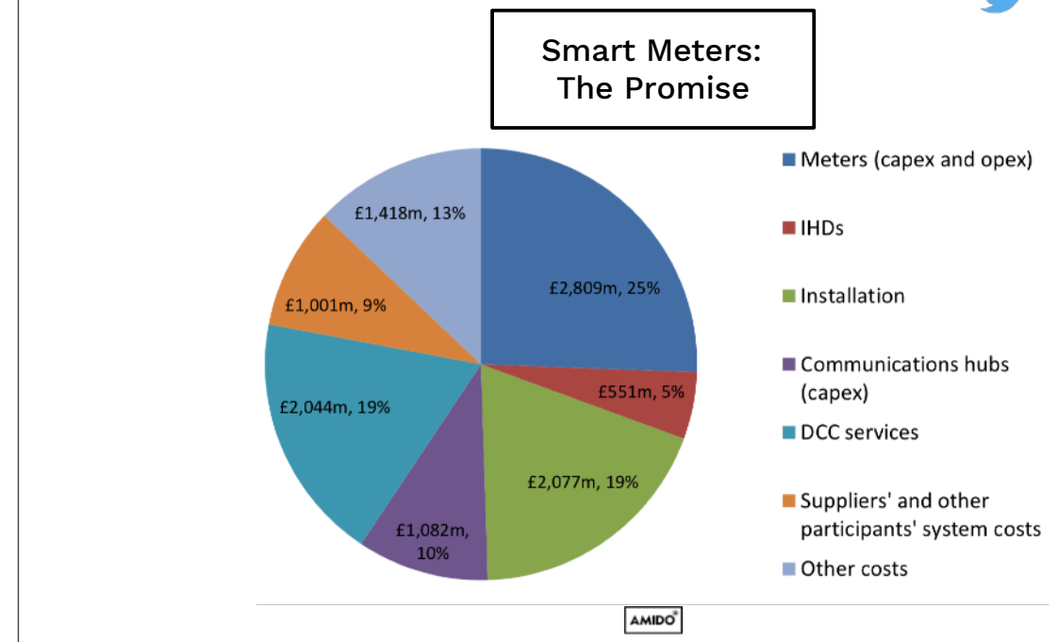


Benefit: £14.3 - 16.7bn

Cost: £10.6 - 10.9bn

AMIDO

@cjrpriest



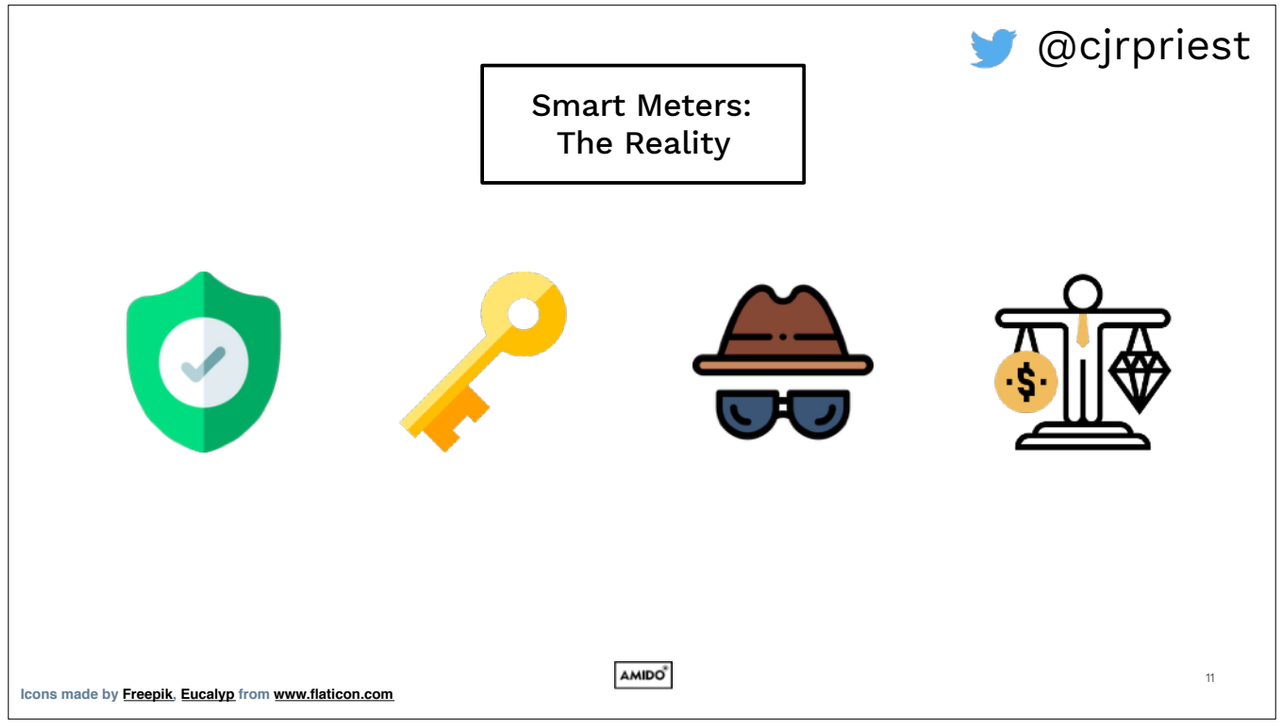
* Costs - ~ £10.6bn - £10.9bn
    * Meters, installation (physical install, commissioning, energy efficiency advice to consumers) + IHDs — 49%
        * £102.58 per meter, if you have gas & electricity, ~£205 per house
    * communication / data costs
    * ‘Other’ costs

* Net benefit of £69 per meter, ~£140 per household

@cjrpriest

Smart meters: the reality

AMIDO



* Security
  * They are absolutely two-way — need to be to send product / price data to your meter so that your In Home Display shows accurate cost data
  * They can remotely cut off the supply
  * Not a concern that suppliers will get ‘trigger happy’ (there are strict regulations against your supplier switching off / disconnecting struggling customers without first helping them to pay their bills)
    * Worth nothing that apparently energy companies are loath to disconnect unless you are using the electricity for health reasons, or reconnect in case you’ve left the oven on (https://www.smartme.co.uk/how-they-work.html)
  * How susceptible are energy companies to being hacked?
* Lock-in
  * If you have a SMETS1 meter, everyone loses the benefits if to change supplier — something the industry regular (OFGEM) actively encourages
  * Out of 12 millions smart meter installations, only 1.1 million (as of 5/6/2019 https://www.smartdcc.co.uk) are SMETS 2.
  * SMETS1 meters go direct to supplier — making them locked in
  * SMETS2 meters go via a central network — making them agnostic (https://www.smartdcc.co.uk)
  * No way to tell looking at the meter if it’s SMETS1 or 2
  * Government has said that the plan is to remotely upgrade SMETS1 to SMETS2 meters by 2020, but according to the National Audit Office in December last year, this is not looking likely (https://www.moneysavingexpert.com/news/2018/11/smart-meters-tech-problem-delay/)
* Privacy
  * If a supplier is collecting your data every 30 minutes, they could presumably work out if you are at home, or not. If this data got into the wrong hands…
    * Not implying that a supplier can’t secure data, more likely a bad actor gets access to your energy account due to bad personal security
* Economic
  * There is opinion that the governments own business case is weak (citation needed)
    * it does lack some detail (i’ve read the 30 page document — which for this many £bns seems quite short — just over 1 page per £bn cost or benefit)
    * With the delays that have been encountered, is it really there at all now?
    * One of the main biz case benefits (40% of the benefit) is - customers reducing usage as they gain a better visibility of their usage
      * there is reportedly some surveys that have been done that show that IHDs and SMs initially cause consumption to lower, but that consumption goes back up to normal levels once the novelty has worn off (although I’ve not been able to find the raw data for this myself)

* This is the main one

@cjrpriest

Is there a better way?

AMIDO

Is there a better way to have a smart meter?

@cjrpriest

My electricity meter

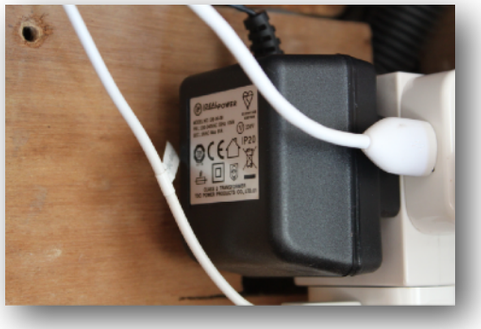
AMIDO

@cjrpriest

AMIDO

* Pretty standard, built in xxxx

My Electricity Meter



* pretty easy to integrate with an electricity meter completely passively

@cjrpriest

My Electricity Meter

OpenEnergyMonitor.org

emoncms
Open-source energy visualisation

AMIDO

* Integrated with by using some open energy monitor equipment
    * APIs to link this to the home automation system of your choice
* Consumption data is published to emoncms.org

@cjrpriest

My Electricity Meter

OpenEnergyMonitor.org

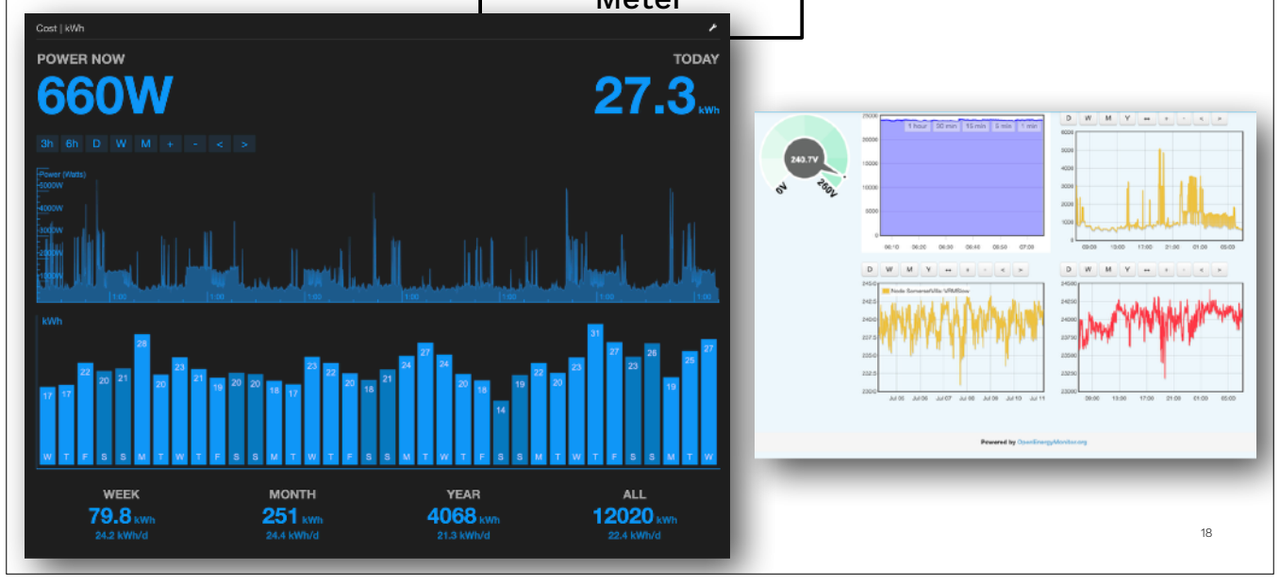
emoncms
Open-source energy visualisation

AMIDO

* Integrated with by using some open energy monitor equipment. About £50, but this is a small scale operation
  * APIs to link this to the home automation system of your choice
* Consumption data is published to emoncms.org

@cjrpriest

My Electricity Meter



* Integrated with by using some open energy monitor equipment
    * APIs to link this to the home automation system of your choice
* Consumption data is published to emoncms.org

@cjrpriest

My gas meter

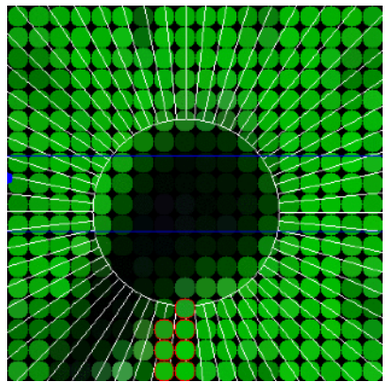
AMIDO

My Gas Meter

AMIDO

* Built in 1984 - it’s 35 years old
* Some later meters had at least some methods for integration, including
    * Rotating reflecting patches or red spots
    * Rotating magnets (reed switch)
    * Or even a flashing light
* Mine has none of this!
* The only (known) (non-invasive / legal) method of integration is visual / optical

My Gas Meter



Dave Berkeley https://www.rotwang.co.uk/projects/gasmeter.html

* No known method existing method

* apart from a solution by Dave Berkeley (https://www.rotwang.co.uk/projects/gasmeter.html)

* This used the optics from a mouse, and some custom electronics, pretty amazing, but is not able to measure within a unit

@cjrpriest

My solution

AMIDO

My Solution
Requirements

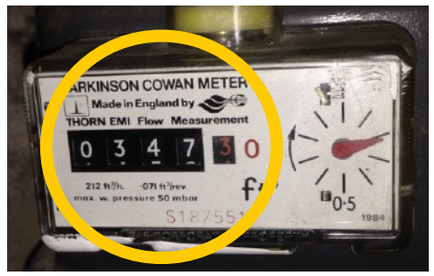
@cjrpriest

- Low cost OTS hardware
- Self-install / low-skill install
- No lock-in (universal gas meter meter compatibility, and energy company compatibility)
- Integrate with any UI / manifestation of usage (e.g. phone app)
- Integrate with centralised usage statistics
- Secure / no cut-off
- Reliable, trustworthy

AMIDO

My Solution

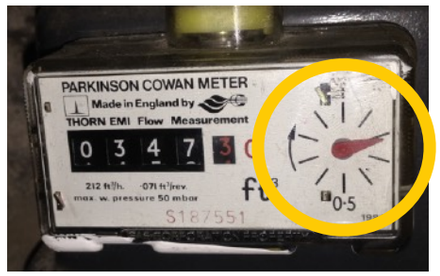
Integration Options



* Integration options
    * Reading the meter numbers
        * Not so accurate — got to wait for a significant amount of gas to pass before a change is registered
            * How to know when to register an increment? Number must be in very precise position
        * Harder integration — OCR is slightly more difficult
        * Do not need to maintain state — any reading a complete independent (& hopefully) accurate reading

My Solution

Integration Options

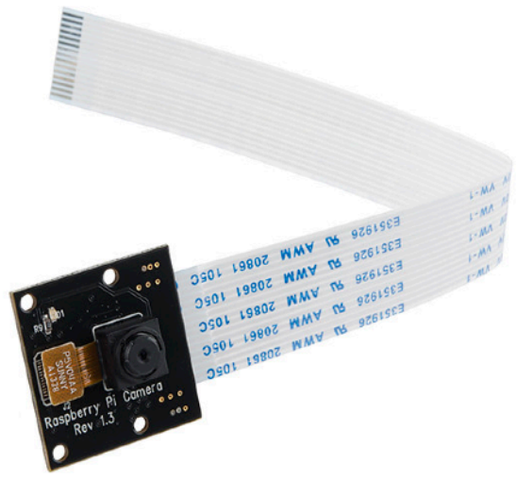


* Reading the dials
    * The most accurate, very real time data
    * Easiest integration — visually just about tracking a dial
    * In order to know what the meter reading is, need to maintain state, and have some story for HA
* Went with watching the meter dial — for me the simplicity, reliability, leading to trust far outweighs the problems to overcome around maintaining state

My Solution - Hardware

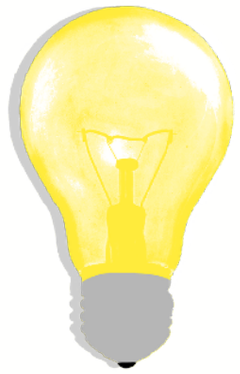
* Technical details
  * Raspberry pi W — cheap, powerful, small, easy to prototype / iterate with
    * Had a raspberry pi since May 2012 — you could say I was an early adopter
    * Good OpenCV story — more later

My Solution - Hardware



* Camera — experimented with USB cameras (webcams) but CPU overhead was high, and reliability was low. Opted for official raspberry pi camera (v1.3) which is more expensive, but leans on the processor less, is rock solid & in terms of resolution is more than adequate

My Solution - Hardware

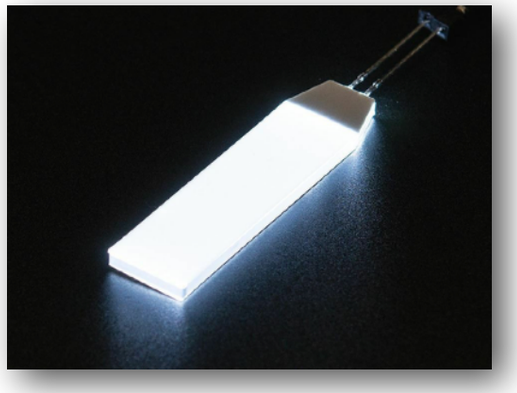


* Lighting
    * Iteration one — a lampshade with the shade removed — tall naked bulb. Ok, but bulky

My Solution - Hardware

* Lighting
  * Iteration two — a RGB LED strip to experiment with colours. Lots of glare, but more compact

My Solution - Hardware



* Lighting
  * Iteration three — a LCD backlight made from a white LED and a slice of acrylic

My Solution - Hardware

* Lighting
  * Iteration four — a selfie light, modified to run from a USB power supply

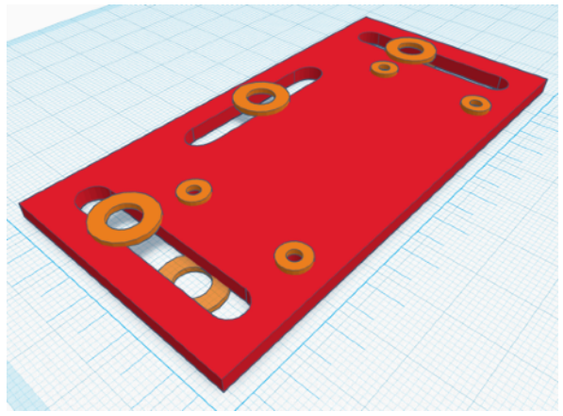
My Solution - Hardware

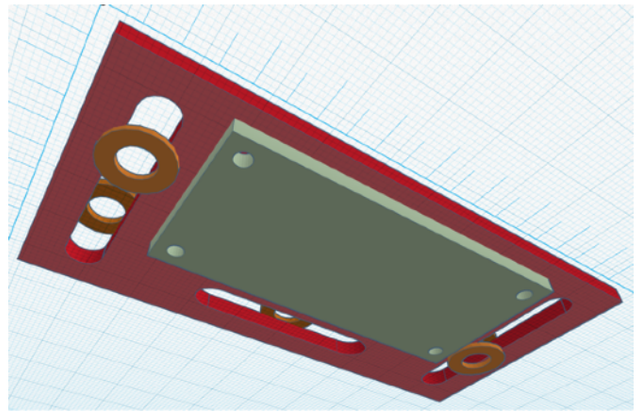
* Stand / mount / platform
  * Iteration one — involved a bent coat hanger and zip ties
    * Raspberry pi resting on an old electrical pattress box
    * Subject to movement, knocks - i.e. not very secure

AUTODESK ® TINKERCAD ™

@cjrpriest

My Solution - Hardware

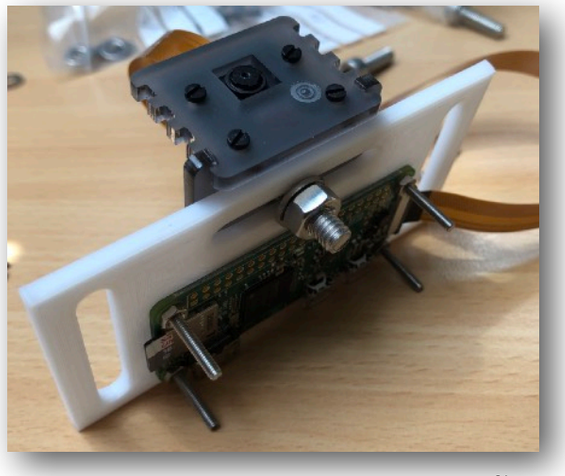




AMIDO

* Stand / mount / platform
    * Iteration two — custom design
        * Design on paper first - important iteration
        * Create 3d model in tinkercad
        * In tinkercad ‘test’ the design with various shapes representing attached things
        * 3D print via 3dcompare.com
        * Bolts & screws from eBay (super cheap)

My Solution - Hardware



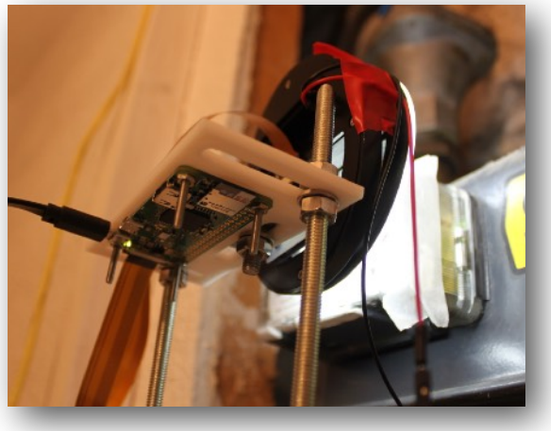
AMIDO

* Stand / mount / platform
    * Iteration two — custom design
        * Design on paper first - important iteration
        * Create 3d model in tinkercad
        * In tinkercad ‘test’ the design with various shapes representing attached things
        * 3D print via 3dcompare.com
        * Bolts & screws from eBay (super cheap)

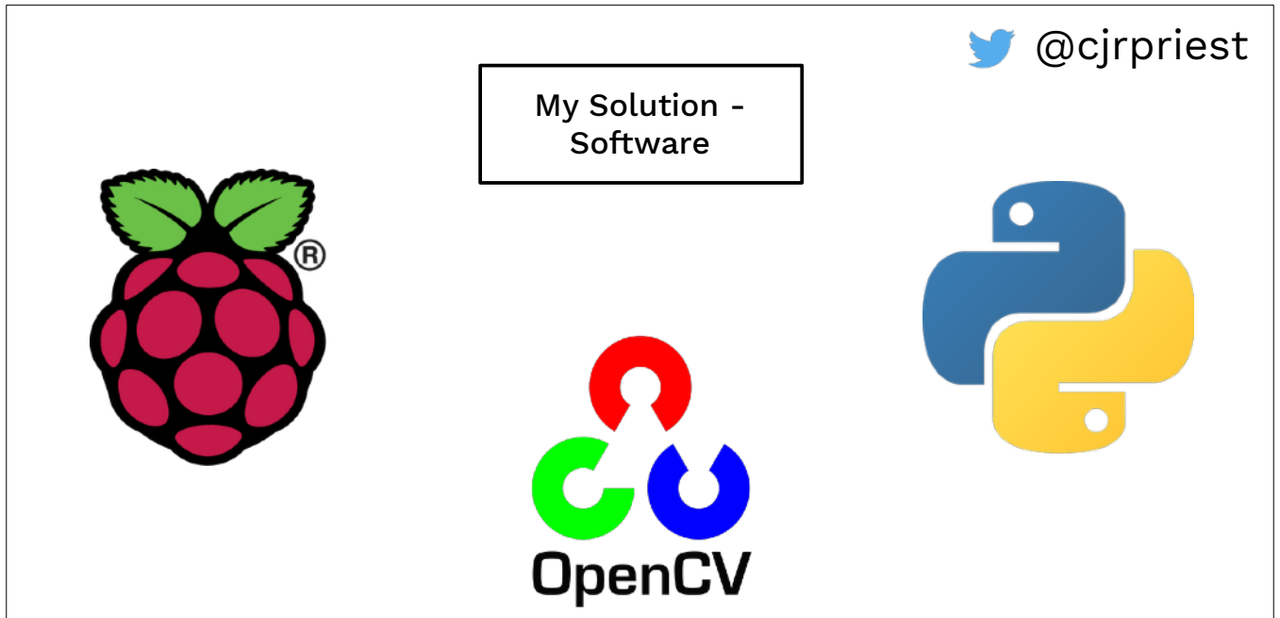
@cjrpriest

* Stand / mount / platform
    * Iteration two — custom design
        * Design on paper first - important iteration
        * Create 3d model in tinkercad
        * In tinkercad ‘test’ the design with various shapes representing attached things
        * 3D print via 3dcompare.com
        * Bolts & screws from eBay (super cheap)

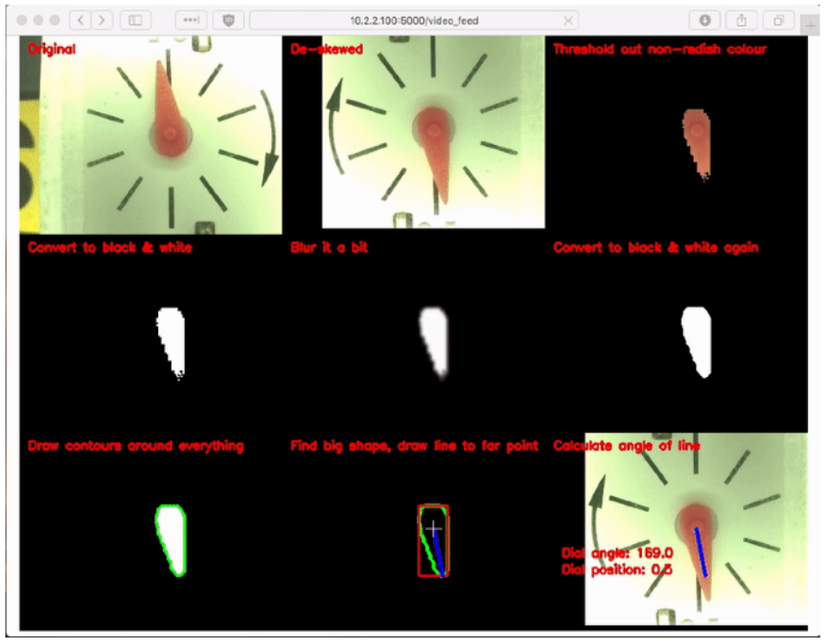
My Solution - Hardware



Bring it all together...



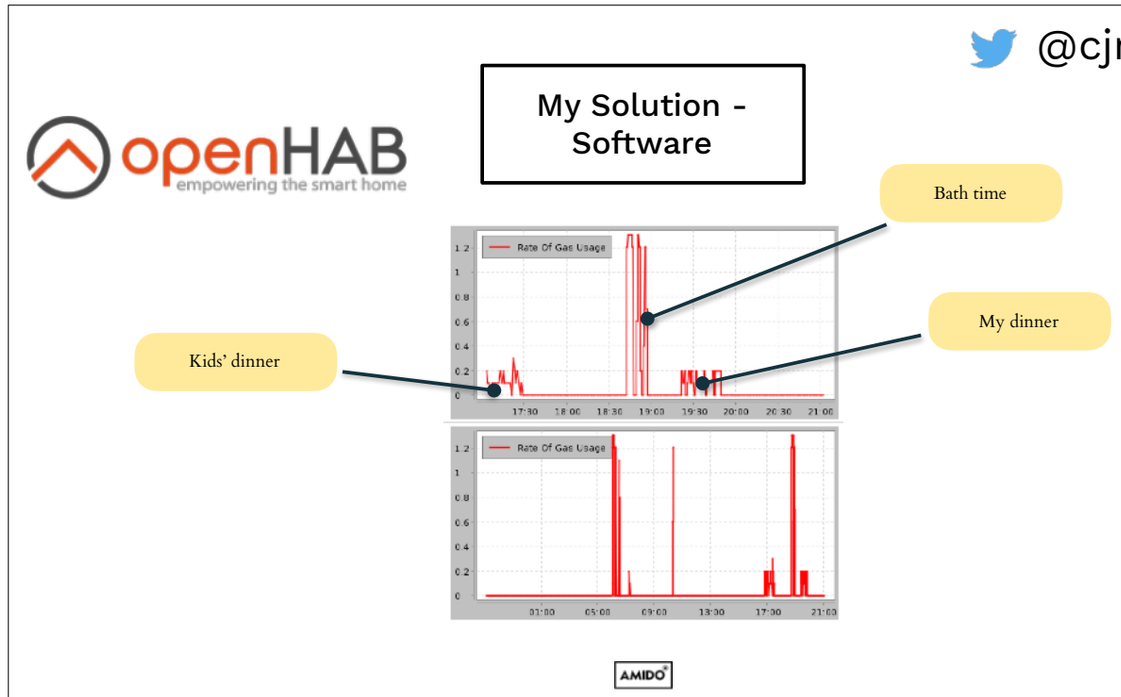
* software
    * Went for the raspbian + Python + OpenCV stack
        * This is well supported in the community, plenty of people working with this combo



@cjrpriest

AMIDO

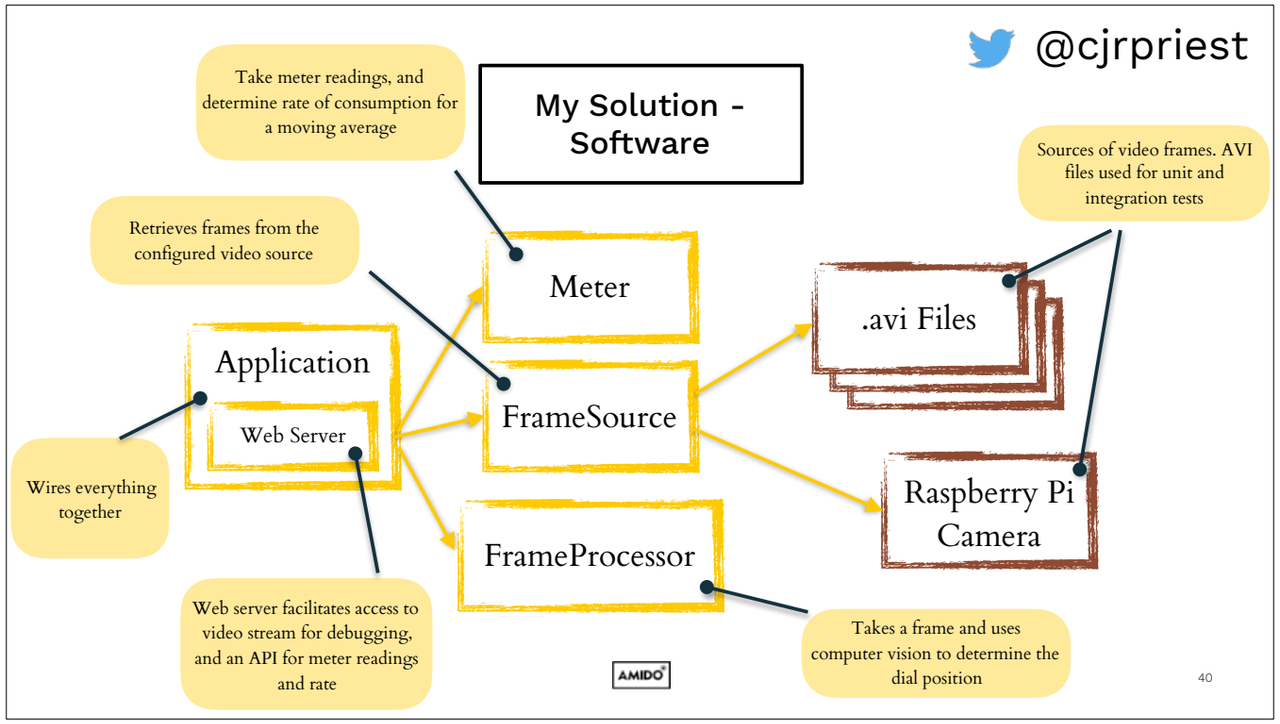
* OpenCV approach to analysing the video from the camera



* I use openhanded for home automation

Configure to query the API exposed by my meter reading software

Produces these graphs

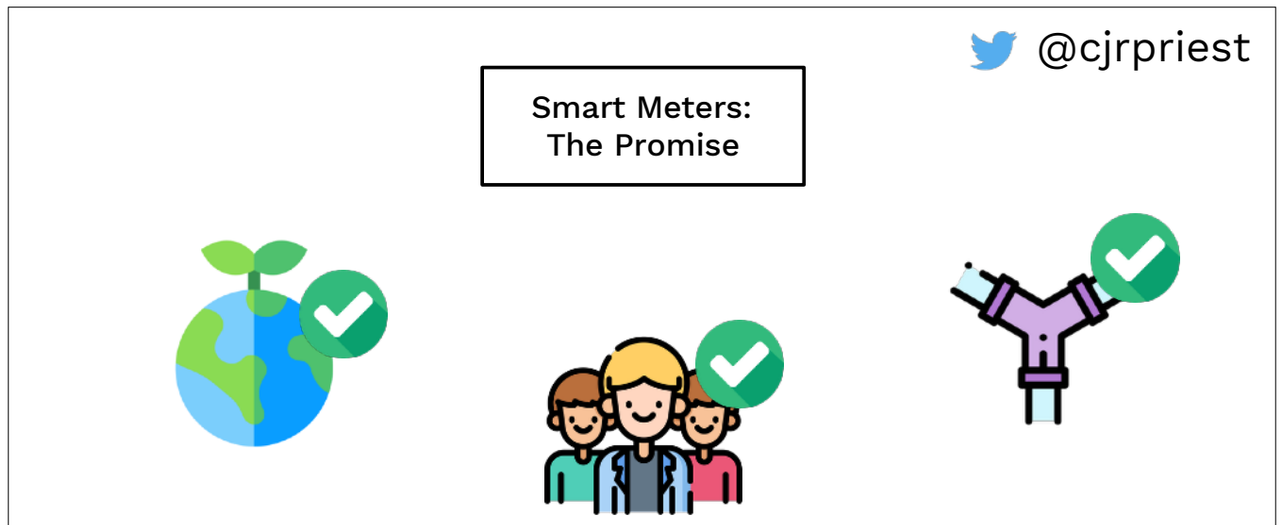


* software approach

@cjrpriest

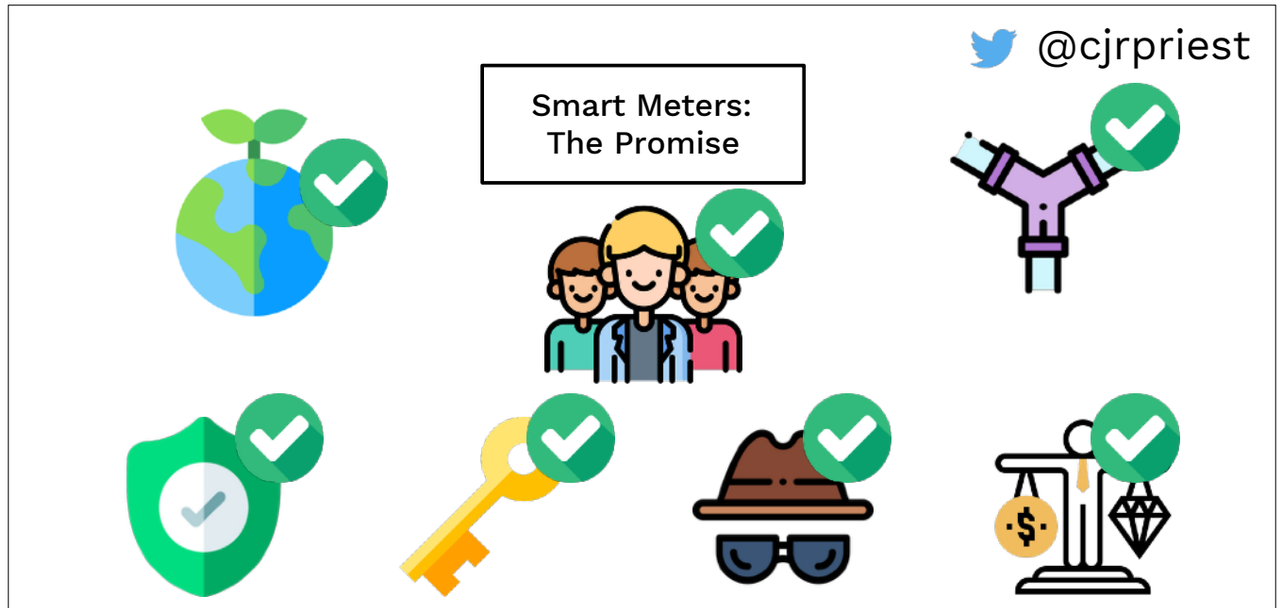
What can the energy industry learn?

AMIDO



Lets remind ourselves of the promise

* In house energy monitor. Reduction in usage. Tick
* lower costs for suppliers: Send meter readings automatically — this can be achieved, although security of the information is a concern. i.e. its probably easily to fake / get lower bills
    * so, if we can solve this with software, we revert to sending a meter reader every few months. Its not clear how much of the 49% of the business case that is around supplier savings relates to site visits, but they would have to remain
        * Also, there is clearly some stuff you could do with machine learning to attempt to spot the signs of fraud — e.g. sudden decrease in usage, spikes / troughs in usage, irregular usage, etc etc
            * You don’t necessarily need an engineer to visit! No specialist electrical or gas skills or certification needed
* Upgrade energy system / smart grid. Tick. No reason why data can’t be shared / centralised. It’s open source too / you can control the message



- No security issues — your supply can't be shut off by this
- No lock in — you are free to use this solution with any supplier
- No trust / privacy issues — you own the data
- More research needed to take this from prototype to production, but should be much cheaper to build
    - And let's remember, the costs are forecast at £205 per household... can this be cheaper than that, at scale?

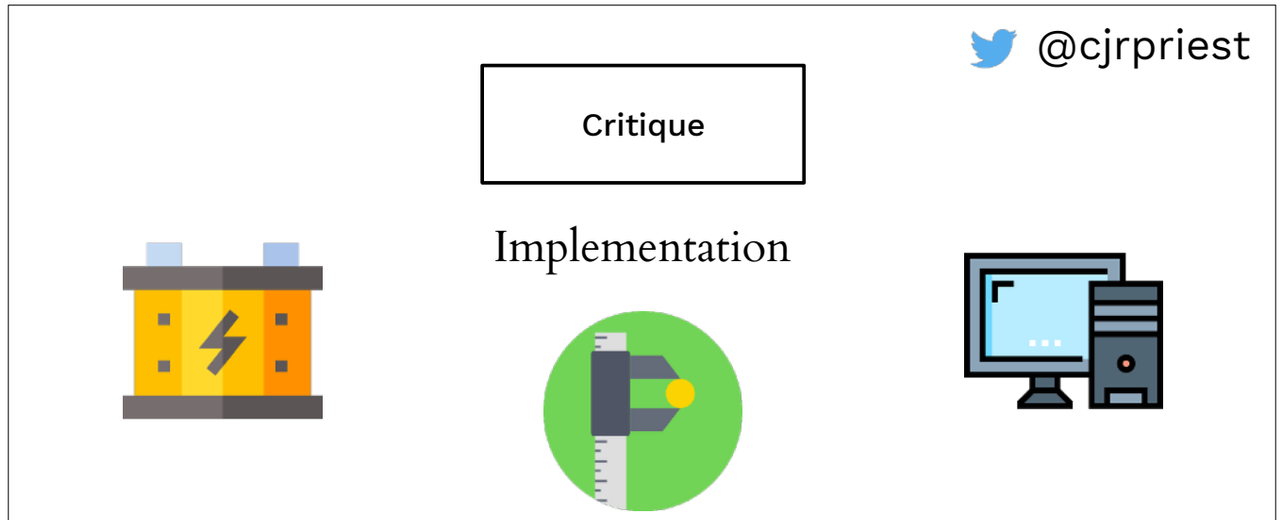
£49 on parts — retail. Bolts, only used about a fifth of what I bought.

rasp pi	£11.59	
selfie light		£3
bolts	£12	
3D print	£10	
rasp pi cam		£12

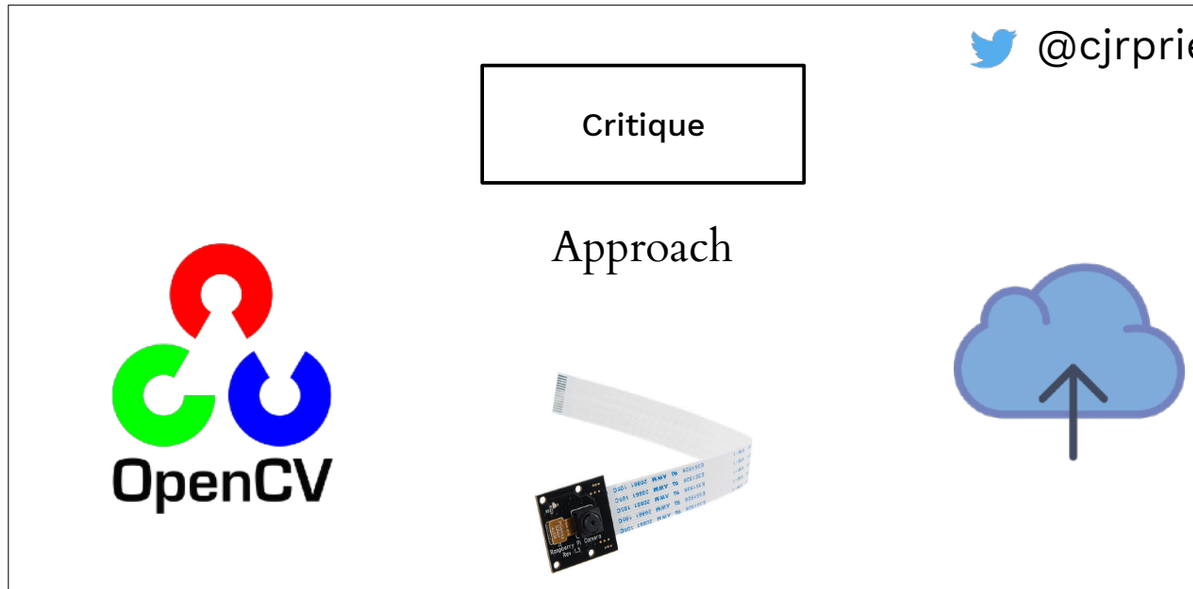
@cjrpriest

Critique

AMIDO



* Of current implementation:
    * My gas meter reader requires a power supply and a local internet connection
        * Needs to continuously monitor the dial, so there is not much of an opportunity to optimise this
        * On the flip side, low voltage supply, safe to run outside etc
        * Traditional smart gas meters have a long-life battery (~10-20 years), utility companies need to replace this during routing checks
    * Requires calibration, most likely a new calibration where lighting changes / is different
        * im sure this could be cracked with further development / investment
        * I'm not a CV expert
    * Requires a full computer with operating system
        * The loop is relatively simple, it seems conceivable that this could run on some simpler, more energy efficient embedded system
        * Requires further development / investment
        * Dave Berkeley managed to integrate the optical sensor of a mouse with an Arduino to read the needle of a meter, so there is something possible there https://www.rotwang.co.uk/projects/gasmeter.html



* By this I mean, was it right to chose the approach to optically reading the meter etc

* Is CV the right approach? Strikes me that if it's possible to train a model to recognise cats, then its probably possible to train a model to learn dial positions

    - I believe there are now low power devices that will run ML models, so might also solve energy problem

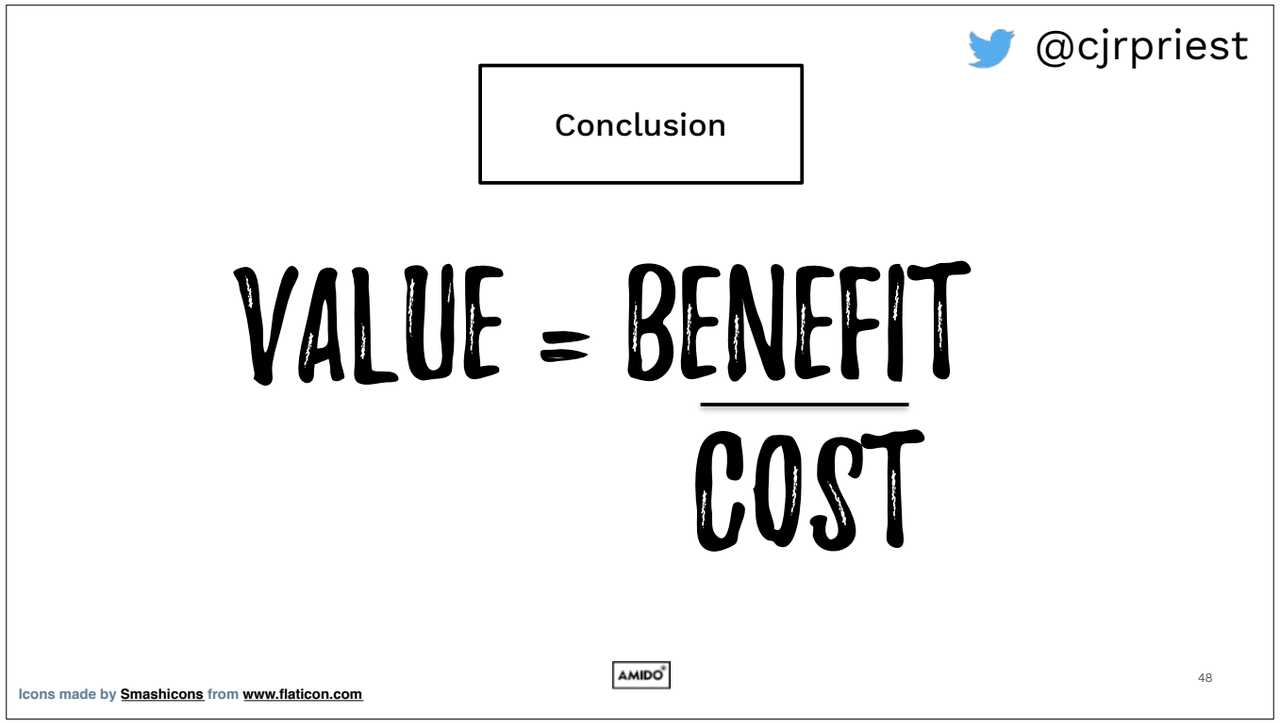
* Is there a better option that a full on camera — something in between Dave Berkely's mouse optical sensor option and a full on camera

* Simpler — send photos of the complete meter face into the cloud every 30 mins? Hour? 24 hours?

@cjrpriest

Conclusion

AMIDO



* OK, I'm probably not going to stop the national roll out of smart meters

* But my hope is that someone will see this talk and rethink that next gold-plated project

* so, if you are measuring value as the return or benefit of doing a thing, divided by the cost of doing it, then consider this:

* Often there is way to achieving a goal using existing cheap OTS parts / services — it might only achieve 80/90% of the stated objectives, but you need to ask the question, is it still the highest value thing to do to build a custom solution?

@cjrpriest

Conclusion

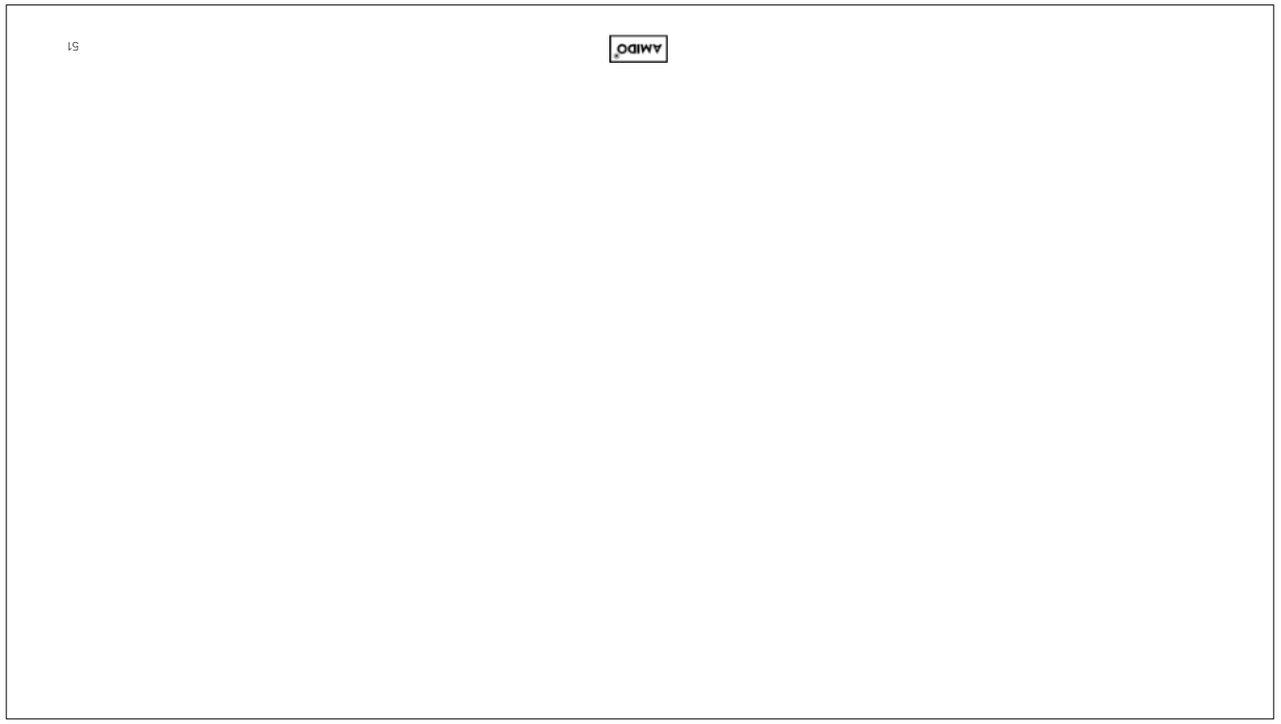
VALUE = BENEFIT / COST

RENT > BUY > BUILD

* And think about applying this approach to your software projects — Rent > Buy > Build
    * It’s often not the highest value thing to create a complete thing from scratch

Thanks for listening!

There was a lot of content here, please see my site for a copy of this talk.


AMIDO

@cjrpriest

My electricity meter

AMIDO

@cjrpriest

AMIDO

* Pretty standard, built in xxxx

@cjrpriest

My Electricity Meter

$$W = V I$$

AMIDO

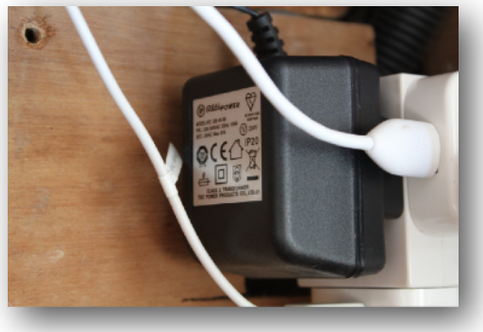
* we can actually integrate with a electricity meter quite easily, and completely passively

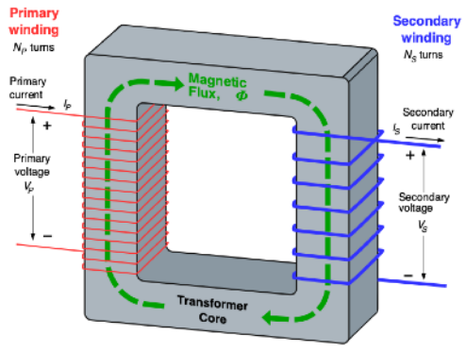
* In order to understand how much energy is being used (W), we need to know current & voltage, as W = V x I

@cjrpriest

My Electricity Meter

V





AMIDO

* For voltage, we use a simple 9v AC to AC transformer. We measure the voltage in the ~-9 to +9v range

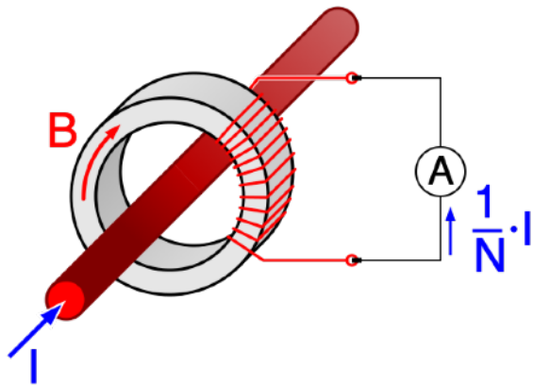
My Electricity Meter

$$W = V I$$

@cjrpriest

My Electricity Meter

I



AMIDO

* For current, we use a Current Transformer
    * AC current, going backwards and forwards, induces a magnetic field in a steel ring
    * The magnetic field in the steel ring, induces a (much smaller, but relatively sized) current in a secondary coil
    * Current in secondary is measured with an ammeter

My Electricity Meter

$$W = V I$$

@cjrpriest

My Electricity Meter

W

OpenEnergyMonitor.org

emoncms
Open-source energy visualisation

AMIDO

* Integrated with by using some open energy monitor equipment
    * APIs to link this to the home automation system of your choice
* Consumption data is published to emoncms.org

@cjrpriest

My Electricity Meter

W

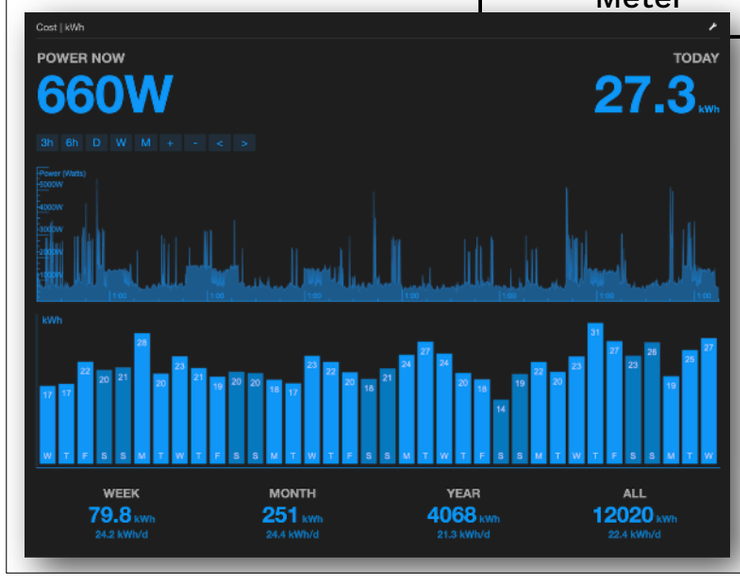
OpenEnergyMonitor.org

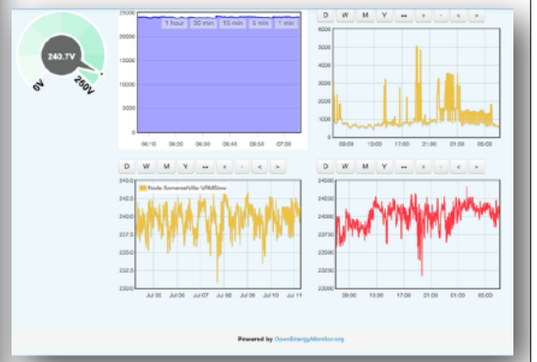
emoncms
Open-source energy visualisation

AMIDO

* Integrated with by using some open energy monitor equipment. About £50, but this is a small scale operation
  * APIs to link this to the home automation system of your choice
* Consumption data is published to emoncms.org

My Electricity Meter





* Integrated with by using some open energy monitor equipment
    * APIs to link this to the home automation system of your choice
* Consumption data is published to emoncms.org