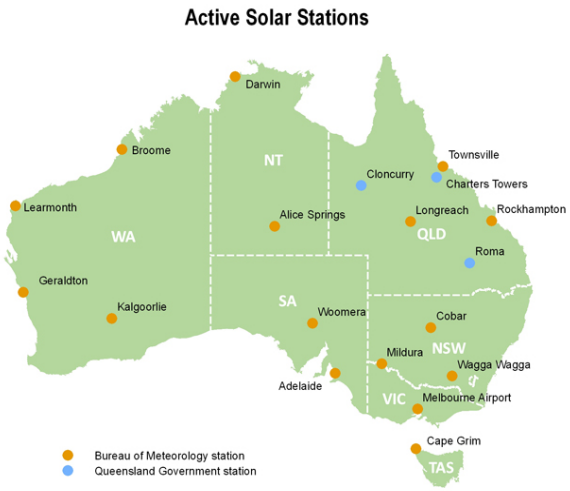
Team name: Wala* - The solar nomad

**Sun goddess - from Australian aboriginal mythology*

1. Mission (problem statement)

The current solar data coverage across Australia is very sparse (16 active solar stations). Historical and widespread data is needed to justify investments into solar PV. Conventional high precision monitoring stations are complex, expensive (~$120k), stationary and hence rarely installed.



http://www.ga.gov.au/scientific-topics/energy/resources/other-renewable-energy-resources/solar-energy/active-solar-ground-stations-across-australia

The energy & weather data typically used for simulation of building and PV or CSP plant performance is based on a hypothetical “typical” year which blends monthly real data from different years with satellite estimates of solar irradiance. These “typical month year” datasets, with hourly resolution, are available at 78 airports/locations in Australia, but the solar data is based on **satellite estimates** of the solar resource, not ground measurements. Downloadable from

https://energyplus.net/weather-region/southwest_pacific_wmo_region_5/AUS%20%20

ARENA just spent $5 million to address this problem:
“Better and more accessible data is needed to help the solar industry identify the regions in Australia best suited for further detailed investigation and potential development of solar energy generation. Such data can also help to improve understanding of Australia’s solar radiation patterns and develop tools to improve their prediction.”
http://arena.gov.au/project/solar-resource-mapping-project/

2. Solution

Due to the rise of the IoT, small hardware has become extremely cheap with a myriad of sensors available. This creates an opportunity for a low-cost and highly mobile sensor system. In addition to the current stationary system, this mobile sensor mesh could greatly improve the sensor reach.

By mounting the low-cost mobile solar radiation sensor Wala on top of moving vehicles we will revolutionise the way solar data is collected. With our approach we can collect irradiance data over a large number of locations across Australia. In this way it is possible to overcome the problem that this data is currently only available in a few locations where stationary systems are installed.

We will use vehicles that regularly move outside metropolitan areas in order to cover rural areas. Backpacker vans or camping vehicles could be utilised for this purpose, as everyone knows they follow the sun! Wala can also be mounted on trucks or trains, which operate regularly on certain routes. Along those tracks a higher data density can be achieved.

Solar irradiance data is collected with the Wala device. This system autonomously collects the data during the trip of the vehicle with a timestamp and GPS location. Data is saved on the internal storage of the device (SD card) and can be downloaded via wifi. If the vehicle drives into the range of the **fon** wifi network, the transmission of the collected data is automatically processed. (for a description of **fon** see below) The **fon** network has been chosen for the project as it will be free to use for the device without any intervention required from the driver, with access to 19 million hotspots all over the world..

Once uploaded into the cloud, the data will be processed in order to reduce noise. The cleaned data will then be used to update the open solar map. As a platform it is planned to use the National Renewable Energy map.

When the collected data is visualised in a map it is simple to use for a broad range of potential users which can greatly benefit the community and the solar energy industry.

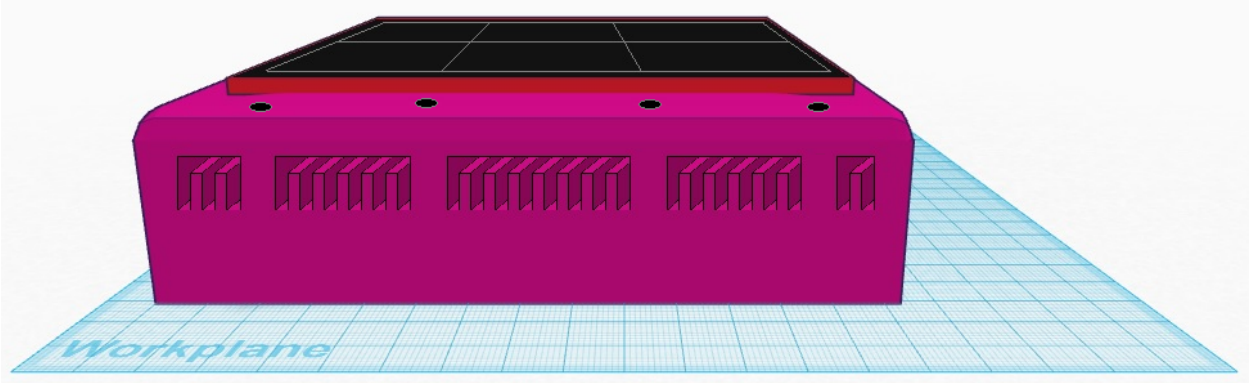
Architecture

The Wala (sensor)

This is the central data acquisition unit. It will be mounted non-invasively on top of vehicles with the help of neodymium magnets. Wala is a small box where all necessary hardware is stored that is necessary to collect, save and transmit global horizontal irradiance data. This system is based around the arduino module. This box can be extended by other sensors to collect further data if required.

Wala is designed to be a zero maintenance device. It operates autonomously while powered by a pv cell which feeds a rechargeable high temperature battery. It automatically collects data and updates those into the cloud when wifi connection is available. As long as Wala is securely installed on the top of a vehicle it requires no more than occasional cleaning.

Arduino Uno R3	$5
Real time clock module	$4.75
Gyro	$4
4 photo pin diodes (3 with filter)	$4
3.3-5V Input Photodiode Module Arduino Raspberry pi (x4)	$4
Temperature/Humidity/Barometric shield	$1.20
GPS shield	$18
WiFi shield	$2
Neodymium magnets	<$1
SD card (8GB)	$4
PV module	$5
Boost converter	$5
High temperature Ni-Cd rechargeable battery	$4
3D printed case with heatsink	$5
Consumables (glue, solder, wire)	$1
TOTAL	~$68

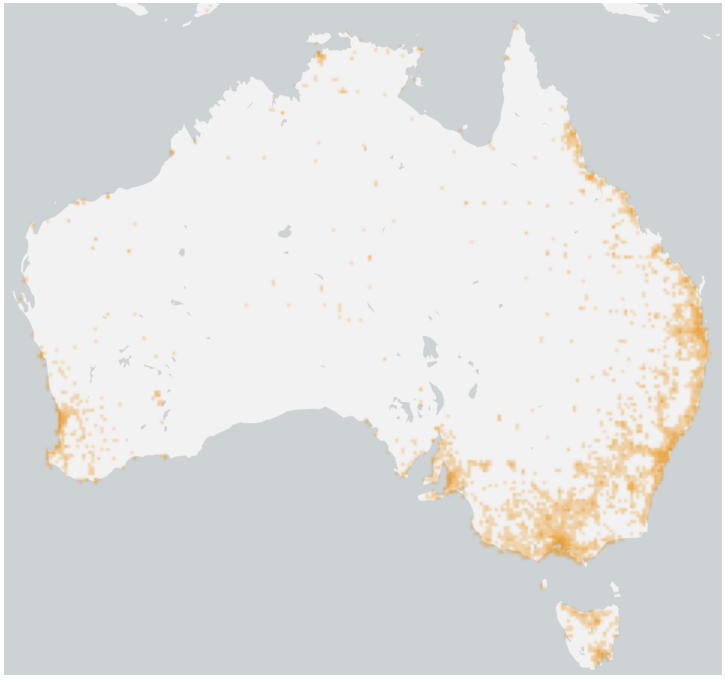


Software

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software (typically C++).

Data endpoint

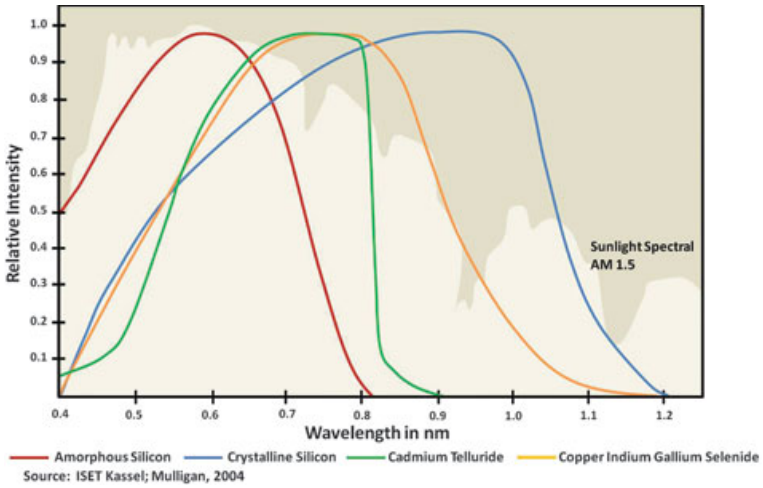
Cloud endpoint for off-loading chunks of data. Off-loading will happen through the **fon** network. **Fon** is a crowdsourced WiFi that allows free usage by participants. The figure shows that fon already has substantial coverage in urban and semi-urban areas of Australia.



http://maps.fon.com/mapContent

Collected Data

A total of 4 photodiodes will be incorporated into the Wala. Three of these will be located behind colour filters to provide basic spectral information. This information could be used by customers to identify the most appropriate commercial solar cell for a particular region.



Solar insolation (shaded area) and the corresponding absorption efficiencies of commercial solar cells.

Any data is measured on ground level, avoiding the errors associated with satellite derived measurements. Different PV types have different spectral responses and use only part of the solar spectrum. A quadrant photodiode would be a cost-efficient first start that allows us to not only measure the Global Horizontal Irradiance (GHI) but also three more disparate wavelengths that could be used to determine the most appropriate PV type.

Every Wala collects data in its particular location at the time. The combined data of many Wala devices is expected to create “solar data highways” on the map which are areas of high data resolution and great opportunity for data use.

3. Potential customers

Primary customer: Our MVP is the creation of an **OpenSolarMap** - and, in the first instance, to provide the acquired data and visualization free for use to anyone.

Second generation customers are expected to come from the solar industry. Increasing solar irradiance data density supports solar project developers, retailers, utilities and network operators in their planning and operations. This would also include Government Agencies (e.g.

Bureau of Meteorology, Agriculture), industry agencies and policy makers that have a strong need to better understand the solar resource in Australia.

Third generation customers are private use customers. This would include farmers, park rangers, trucking companies, train companies, rental camper companies - each of which could use this information in specific ways. For example park rangers could track climate change in remote and isolated parts of Australia and link that to species movement and possible habitat loss.

Fourth generation customers. Once the system has been validated in Australia - it would be straightforward to deploy it across regions like Africa as a path-finder to map solar insolation on that continent. Data of this quality would be of interest to renewable energy companies.

4. User experience

There are two type of user that need to be considered here: the driver of the vehicle hosting the Wala device, and the user looking to explore the data set.

The system is designed to require no intervention from the driver, since the downloading of the data from the Wala to the cloud happens automatically when the unit is in range of a fon wifi hotspot.

The customers - that is those looking to explore the information and make investment decisions based on their findings - will be able to easily access the data through the interface established through the AEMI project, subject of course to vetting by ARENA and NICTA/Data 61.

Competing products/services

The data collected by Wala is in competition to other solar radiation data sources such as stationary and satellite data. We have designed the system in a way so it will complement currently existing data sources.

Wala will be more reliable than satellite data sources as it is collecting real weather data. It will not be provide as consistent and accurate data as a stationary system but instead produce data over a much broader geographical range. A further competing data source that may be accessible in the future is to access data directly from PV systems through smart monitoring. While this source is reliant on existing PV systems, Wala is able to discover new areas for potential solar projects.

5. Impact

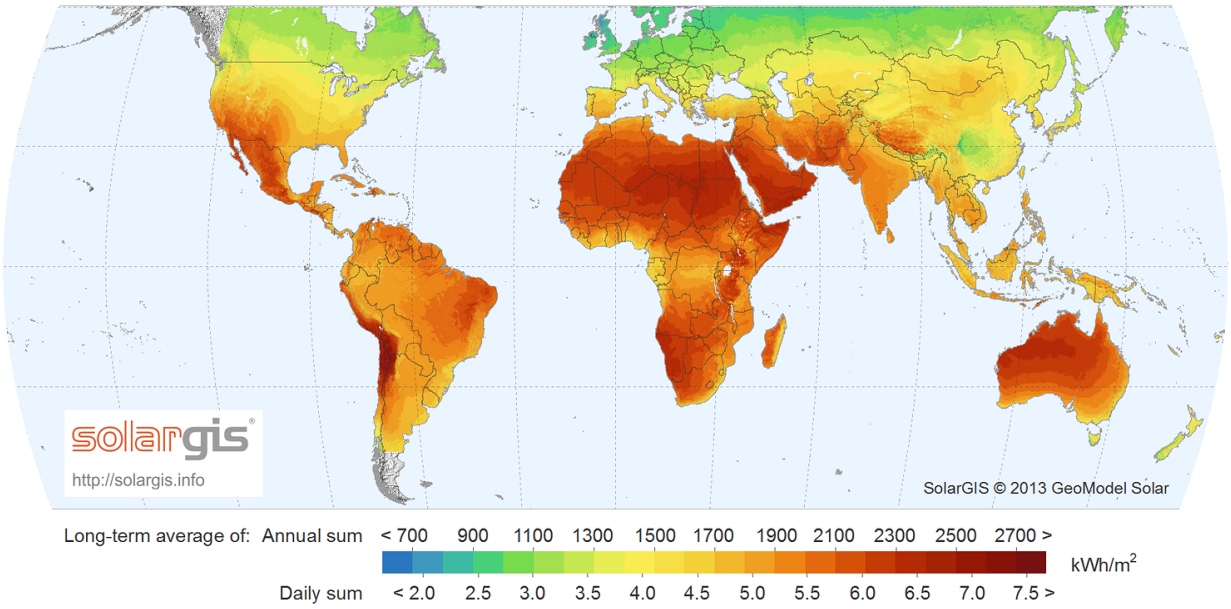
Short term:
Extend the GHI data availability by infilling the very sparse existing data sources.
Provide reference data for validation of other data providers.
Provision of an open solar map usable for any creative use possibly incorporated with the national map for renewable energies http://nationalmap.gov.au/renewables/ .

Long term:
We plan for Wala to be the starting point of a long term solar radiation data collection. Within a few years a substantial amount of solar data will be accumulated which will then have the potential to be used in many applications. Creative innovators will develop opportunities to utilise the data.

Outlook/Roadmap

- Proof that concept works: hook up a nomad next to an established station and compare sensor data
- If the current pace of technology keeps up, the quality of sensors and embedded devices could even allow real time analysis, such as cloud coverage prediction for PV output forecasting.
- Use WiFi mesh network to attach backups of sensor readings onto passing nomads (data retention & faster off-loading)
- Use WiFi mesh network to validate sensor readings of close-by nomads
- Building an historical trend of solar / weather patterns in remote and isolated regions and linking that to species movements (habitat loss etc).
- For an additional $8 you can measure humidity, barometric pressure, temperature.
- A user interface could be provided to a mobile phone app to enable the Nomad to track their trip and share on social media. Imagine kids showing a google map in Show & Tell of their recent holiday
- Aggregated GPS data could provide insights into opportunities for service industries e.g. cafes, surfboard rental

- This image shows why Solar is predicted to be the biggest employer in Africa by 2040...



- **Wala - solar nomad** is a relatively low-cost approach to mapping this resource on the ground.

Risks

Risks	**Solutions**
Shading from trees. What if the nomad is parked under a tree	Ultrasonic sensor could be used to identify if close objects are in sensor field of view Data cleansing algorithms.
Not enough participants/coverage	Explore fleet options: campervan companies, taxis, Uber, trains
Privacy	Anonymously uploaded to map
Data Quality	Calibrate with standard solar simulator lamp

Appendix 1

Elevator pitch: **Guerilla solar data collection on any vehicle**

Teaming:
Intro / how do you feel / Wishes & fears / Skills

Mode of work: agree on license / usage rights of the outcome

Goals/Deliverables for the Hackathon:

- Concept and solutions
- Something tangible?
- Can we “build” the hardware? http://fritzing.org/home/ ? https://123d.circuits.io/ ?

How:

- Arduino w/ WiFi shield / Particle (https://www.particle.io/)
- GPS shield
- Photo sensor
- Store data on SD
- Charging via PV shield for Arduino http://www.voltaicsystems.com/solar-arduino-guide
- Possibly: Gyrometer for tilt detection
- Data off-loading via 3G/fon network: http://maps.fon.com/mapContent
  Or possibly Telstra Hotspots?
- Attachment to car rooftop via neodymium magnets
- Cloud endpoint
- Google maps visualization
- Over-the-air updates with https://resin.io/
- 3D-printed case

Costs:

- ? (Do some estimates)

Why/Incentives:

- Green is “cool” / Doing something good
- Environmental feelgood - more green products/energy than ever before, etc. (proof!)
- Canceling out carbon footprint / “greenwashing”
- Research for the masses
- Technology-affinity
- Adding more sensors is relatively trivial
- Ideally: DIY solar data collection module
- Adopt-a-box: http://www.bookcrossing.com/
- Gamify: Become a daylight robber

Where:

- On cars (camper fleets, e.g. http://jucy.com.au/default.aspx, trucking companies, car rentals, private cars, etc.)
    - Camper cars seem ideal, because people follow the sun and Australia is big, so most of the time there will be something to measure
    - Grey army / grey nomads
- Boats? Jump on the bandwagon with https://seabinproject.com and similar environmental projects (off-loading data might be a problem)
- Airplanes? (off-loading data might be a problem, also 35,000 feet <> ground level resource as above clouds and less air attenuation/scattering)
- Taxis / Uber drivers - great for urban areas
- Trains may be useful as they have regular trips on the same track to build up a time series of data at a particular location

Risks:

- Inaccurate data
- Not enough coverage
- Not enough participants / fleet
- Data off-loading doesn't work
- Overheating
- Nobody needs/wants the data
- Device/management is too expensive
- Box can't be attached, e.g. rooftop is fiberglass (campers!)
- Too much data
- Data not anonymous / solution used for tracking individuals
- Vibrations of the car loosen contacts

Similar technologies / competitors:

- ? (research!)
- Home weather stations (X) none measure solar irradiance

Prior work we can build on / learn from:

- Simon's work
- Possibly Insurancebox?: http://insurancebox.com.au/
- Google street view?
- Home weather stations

Questions:

- What does a datapoint look like?
- Total data volume? (estimation!)
- How long can it work off-grid (SD-card prices)

Crazy ideas:

- Cheap enough to just attach them to arbitrary vehicles? Legal side?