Data Science at Redback

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Agenda

- Who we are
- Our product
- Data Science studies
- Saving money by scheduling battery through prediction and optimization
- Assessment
- Conclusions and Future work

Who we are

GOODWE your solar engine

UNIQUEST

EY Building a better working world

Microsoft Innovation Centre

EnergyAustralia LIGHT THE WAY

Incorporated in April, 2015 with 2 Employees. Today Redback employs 47 people, with 38 employees based in Australia. Redback is located on the University of Queensland's Long Pocket Campus. University of Queensland is an Investor behind the company and has developed an IP collaboration and commercialization agreement that sees Redback leveraging UQ technology across the fields of Electrical Engineering, Information Technology, Economics, Business and Policy.

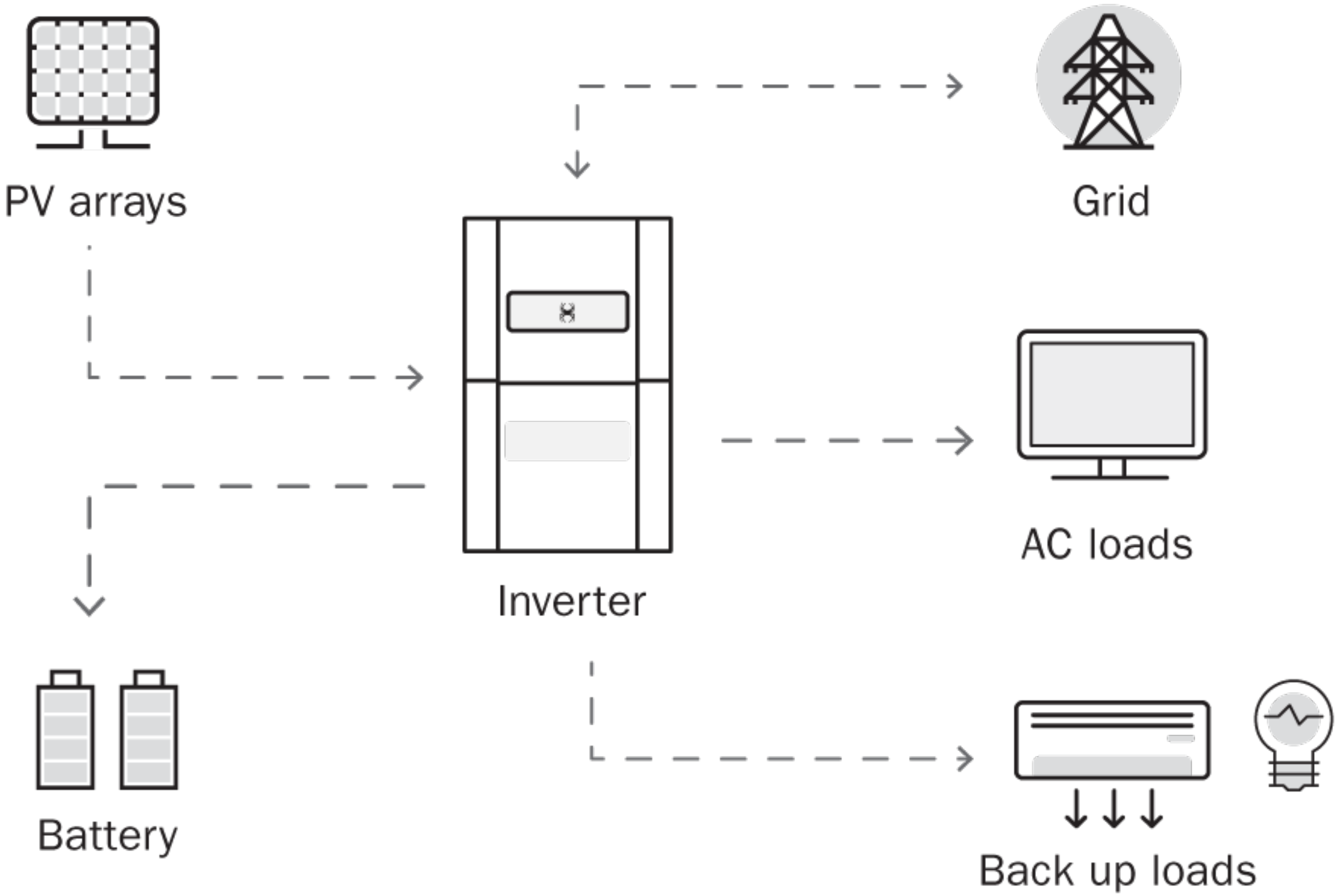
Redback Technologies

- Australian manufacturer of smart solar inverters
- Inverters to store, monitor and manage a home’s solar energy
- Based in Brisbane (Indooroopilly) and Suzhou
- Customers can choose battery (e.g. lithium ion, zinc bromide, lead acid)
- Customers choose inverter panel size and type
- Agnostic to battery type
- Ability to schedule relays (IoT)
- Inverter models: SH4600, SH5000 – maximum AC power to grid

Redback Technologies

- About 1,300 active sites across Australia and NZ
- Load and solar data is sent to cloud storage over wi-fi whenever possible
- Different measurements on the inverter for accuracy and calibration – instantaneous values at one minute intervals and internal counter updated at five second intervals
- Data can be available at resolution of approximately one minute

Diagram



Data science aspects

- Data cleaning/quality and storage
- Network intelligence
    - Solar and load forecasting
    - Phase identification
    - Fault detection using smart meters
    - Broken neutral detection
    - Detecting grid parameters outside allowable ranges
- Load control
- Data compression
- Load disaggregation
- Data security requirements

Ouija Lite devices

- Measurement of voltage, current and resistance at regular intervals
- Collect and store data, used to assist DNSP (distribution network service provider) to detect faults in distribution network
- Ownership of data
- Privacy considerations
- Security of data, and transmission – IoT device CPU limitations

Data cleaning, quality, compression and storage

- About 1,300 inverters registered with locations
- One system status recorded every minute; load, PV voltage, grid import/export; current, power; state of charge; times of status; error messages in JSON format
- Based on inverter internal format e.g. two byte variable for daily cumulative kWh total of PV, resetting at midnight
- Daylight saving changes and midnight resets are significant issues
- Azure data tables – speed of access; 1 million records/minute to CSV
- SQL queries
- Data compression becomes an issue – in fact, what should be stored and at what resolution? What is underlying precision of data? FP or Integer?

Network intelligence

- Phase identification
- Broken neutral detection
- Fault detection with smart meters
  - A heavily studied area – literature review paper - “High Impedance Fault Detection” Ghaderi, Ginn and Mohammadpour (2017) lists 210 references
- Load disaggregation – since 1980s. Pecan Street Dataport.
- Load and PV forecasting – Global Energy Forecasting Competition (GEFcom) in 2014

Load disaggregation

- Also known as NILM (non-intrusive load monitoring)
- Taking readings (resolution 20 kHz – 1 Hz) from house load
- Disaggregating into energy end use (e.g. refrigeration, lighting, heat, microwave, computers etc) in real time or by month, quarter etc
- Faulty or inefficient appliance detection
- A science in its infancy
- Companies offering services include Green Running, Bidgely, EEme etc
- See http://wiki.nilm.eu
- NILM 2018 conference playlist on YouTube

Battery scheduling

- The “default” approach for instantaneous energy management used in the Redback inverter
- First, load is met (in order) by:
  - Solar energy
  - Battery energy
  - Grid energy
- After this procedure is applied, any left over energy is sent (in order) to:
  - Battery
  - Grid

Limitations of “default” approach

It’s not the optimal approach
We want to lower the customer’s energy bills

- Default approach does not know about:
  - Time of use tariffs at the household
  - Location of inverters – sunrise, sunset times
  - Location of inverters – weather forecast (radiation, clouds etc)
  - Past load and PV data
- The alternative to “default” with Redback inverters is:
  - Inverter can be commanded to maintain a charge or discharge rate, or set back to “default” at any time (depending on connectivity)
  - These commands can be ignored if they would violate battery State of Charge boundaries

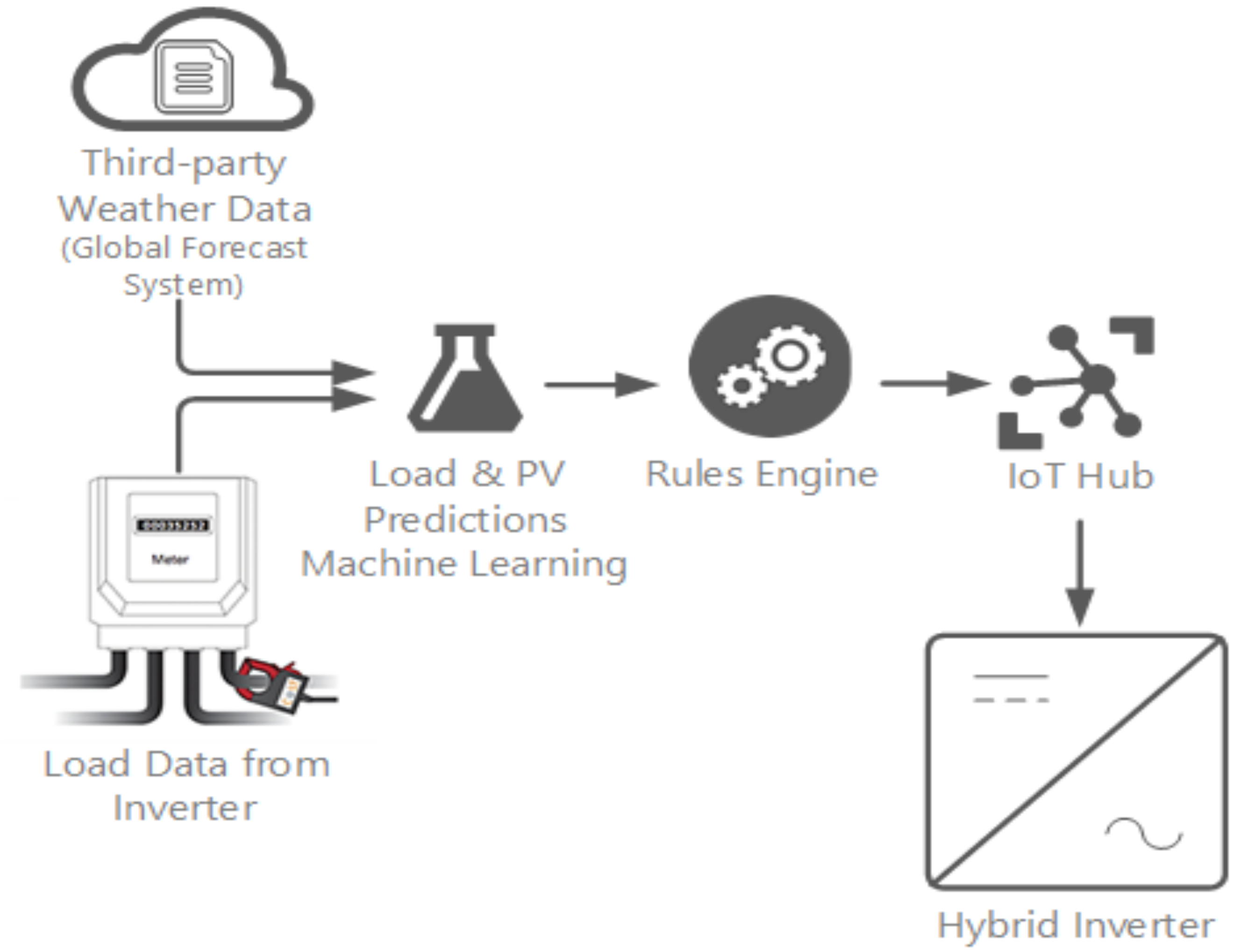
Improve default approach

- Objective for Redback is to save customers money over the default approach while never losing money (over long-term)
- Forecast errors may lose money at a particular inverter in the short term
- These errors are much more costly in peak
- Ideally we would have a command based on a perfect load and PV forecast at a fine resolution (e.g. 10 to 15 minute resolution)
- Load and PV forecast can be useful 24 hours into the future (daily discharge)

Forecasting solar and load

- At Redback, the properties of each inverter (e.g. size, orientation, shading effects) are in general not known and must be derived from observations
- Cloud detection and prediction e.g. using cameras not viable
- Numerical weather prediction (NWP) approaches
- NWP providers
  - Bureau of Meteorology (BOM)
  - National Weather Service (GFS)
  - European Centre for Medium-range Weather Forecasts (ECMWF)
- Assimilation/analysis step

Diagram


Third-party
Weather Data
(Global Forecast
System)
Load & PV
Predictions
Machine Learning
Rules Engine
IoT Hub
Meter
Load Data from
Inverter
Hybrid Inverter

Conclusions on prediction and optimization

- The approach is successful, depending on some factors
- Using hourly simulation, the optimisation saves 1-10% over the default approach (with an aggressive tariff), compared to 7-23% if a perfect PV and load forecast was available
- With tariffs where the peak and off-peak prices are closer together, savings are lower

Conclusions

- Smart meter data analysis has great potential for fault identification for DNSPs
- Smart inverters as groups can also be used in larger scale enterprises e.g. Virtual Power Plants, Embedded Networks, Demand Response for AEMO
- This requires group prediction and optimization, and trading
- Potential for ancillary services market participation
- Scope for studies in behavioural economics – getting homeowners to cooperate to reduce their bills. Pricing in VPPs and theoretical proofs are important
- Security and encryption issues around data storage and IoT communications

REDBACK TECHNOLOGIES

Thankyou

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