

# Battery Storage Design for Grid Connected Systems

SEIA PD Day; Solar 2015

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# Storage – the hype and the reality

- Everyone asks for storage
- ~1% actually go ahead, though some specialise
- At least there can be some profit in it
- Tesla has got everyone even more excited... but when will it be available in Australia
- Australian conditions ripe for Energy Storage (TOU, self-consumption incentive)
- How to approach the market

# Rules of thumb are really really really difficult

- We have built a sophisticated excel sheet to perform hour-by-hour modelling
- We will summarise lessons learned and generalise them, to assist in your design
- We can assist you with sizing and evaluating systems on a case-by-case basis. Alternatively you too could become an expert on HOMER software

# Rule #1... hideously complex design for optimal financial outcome

- **The “Absorb all of the PV generation” approach leads to under-utilisation of the battery**
  - **Just like PV has financial diminishing returns, so does battery volume**
- Understanding the Energy Consumption Profile is key and critical, even moreso than for PV alone
- Consider whether switching to TOU will affect their bill
- Should you focus upon arbitrage or avoided solar exports
- How do technical factors affect things
  - battery dis/charge regimen and
  - max rate of charge/discharge and battery capacity
- Cycle Life

# Two approaches

## **Arbitrage**

- Discharge batteries during peak periods
- Charge batteries from off-peak energy
  - Any solar energy would likely be exported as batteries would start the day full
- Its possible to offer a Tesla battery-only solution with 13 year payback in Ausgrid territory

## **Export Avoidance**

- Charge the batteries from energy that would otherwise be export
- Discharge batteries as soon as the solar exports cease – accept peak or shoulder rate
- Pre-discharge batteries in the morning so they're empty and can absorb as much PV as possible
- Its possible to offer a 5kW PV system with 7kW Tesla batteries with 7.6 year payback... well into Early Adopter territory

# Simplistic approach: ARBITRAGE with Tesla

- Origin Ausgrid TOU 51c peak, 19.8c shoulder, 11.1c off-peak
- Arbitrage only (no PV): Shifting 7kWh from peak pricing into off-peak (weekdays) or shoulder (weekends):
  - Cost =  $7 * 1.1(\text{efficiency}) * \$0.111 * 365 = \$312/\text{year}$
  - Saving =  $7 * (5/7 * \$0.51 + 2/7 * 19.8) * 365 = \$1075/\text{year}$
  - **Net Benefit: \$763/year**
- Cost of Tesla installed = USD\$3500 / A\$0.80 = A\$4375, plus 3kW inverter (\$900) and installation \$950 = \$6225.
- Add 30% profit margin and then 10% GST. **Total Cost \$8901 inc GST**
- Best case payback = 12 years assuming \$0 maintenance. (8.6% ROI)
- In reality batteries may not fully discharge each night (e.g. if energy consumption during peak period is < 7kWh) ... **payback 14 years**
- Other jurisdictions have less scope CitiPower 16c off-peak & 32c peak – never pays back

# Simplistic approach (detailed to come) 100% effective PV shifting with Tesla

- Origin Ausgrid TOU 51c peak, 19.8c shoulder, 11.1c off-peak
- Arbitrage only (no PV): Shifting 7kWh from export into peak (weekdays)/shoulder (weekends):
  - Cost =  $7 * 1.1(\text{efficiency}) * \$0.06 * 365 = \$169/\text{year}$
  - Benefit =  $7 * (5/7 * \$0.51 + 2/7 * 19.8) * 365 = \$1075/\text{year}$
  - Net: \$906
- Cost of unit Total \$8901.
- Best case **Battery payback = 9.8 years** assuming \$0 maintenance. (10% ROI)
- **Actual case: 15 years (for those with 5kW of PV already installed)**
- **But System payback approaching 7 years!**

“There’s no way we can possibly satisfy this demand this year,” Musk admitted.  
“We’re basically sold out through the first half of next year.”

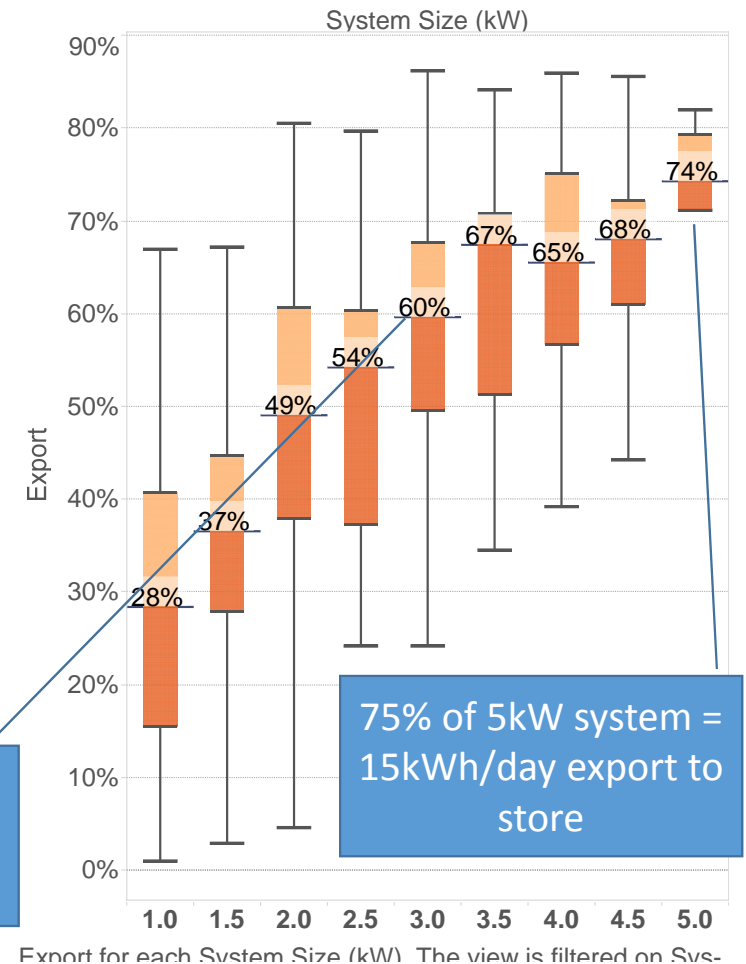
# Export ~~Avoidance~~ Minimisation Approach

- Consider: is it possible to absorb all the solar export?
  - 5kW system produces 20kWh/day average
    - Problem #1: top 25% of consumers!!!
  - 5.5kWh/kWp/day of production in daylight reasonable summer's day. = 27.5kWh of generation
    - Problem #2: 7kWh of storage
  - If 7kWh of it is absorbed by batteries, the rest must be self-consumed... or will still be export.
    - Problem #3: Unless the customer has 20.5kWh of daytime load, then there will be exports!



# Export ~~Avoidance~~ Minimisation Approach

- All of these battery-backup systems with 2-5kWh of storage will have minimal effect on reducing export
- In simple terms, the batteries readily fill, and overflow!
- Should I go for a bigger battery bank?
  - Financially & Energetically, there are diminishing returns from upsized batteries
  - With lead-acid, lifetime is a function of depth-of-discharge, so there may be some long-term value in larger batteries.
  - The first kWh of storage does the most work in reducing export... the second kWh does a bit less... and so on. But there are also fixed costs of installation, so sweet spots will exist.
- Sweet spots with vary from customer to customer



60% of 3kW system = 7.2kWh/day export to store

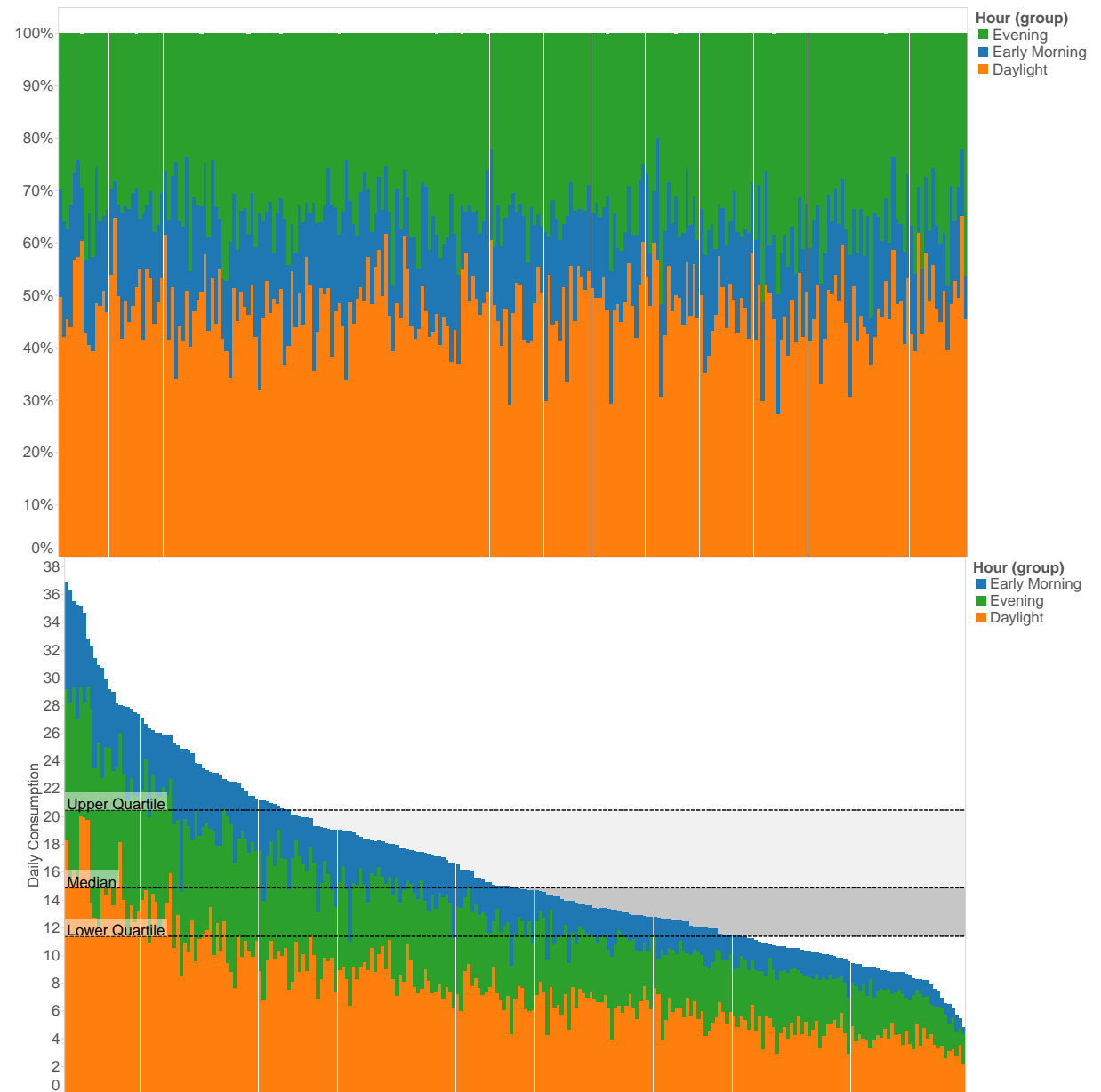
75% of 5kW system = 15kWh/day export to store

Q: Is there sufficient solar PV capacity to run daytime loads as well as recharge batteries or is an increase required?

**A: In most cases there is already more than enough PV capacity installed on existing systems to recharge batteries**

## Sizing: Step 1

- Understanding Total consumption
  - Median: 15kWh/day
  - 50% of Ausgrid solar customers between 11 – 20kWh/day
  - Google SunWiz Export Calculator for free calculations of export from various system sizes
- High-level understanding of consumption profile: What % is daytime use?
  - ~ 45% is Daytime Load (7:00am-5:59pm)
  - ~ 35% is Evening load (7pm-midnight)
  - Rest is Early Morning
  - Therefore daytime load is 4-10kWh/day = 1-2.5kW of PV
- Therefore the rest of the PV must be stored



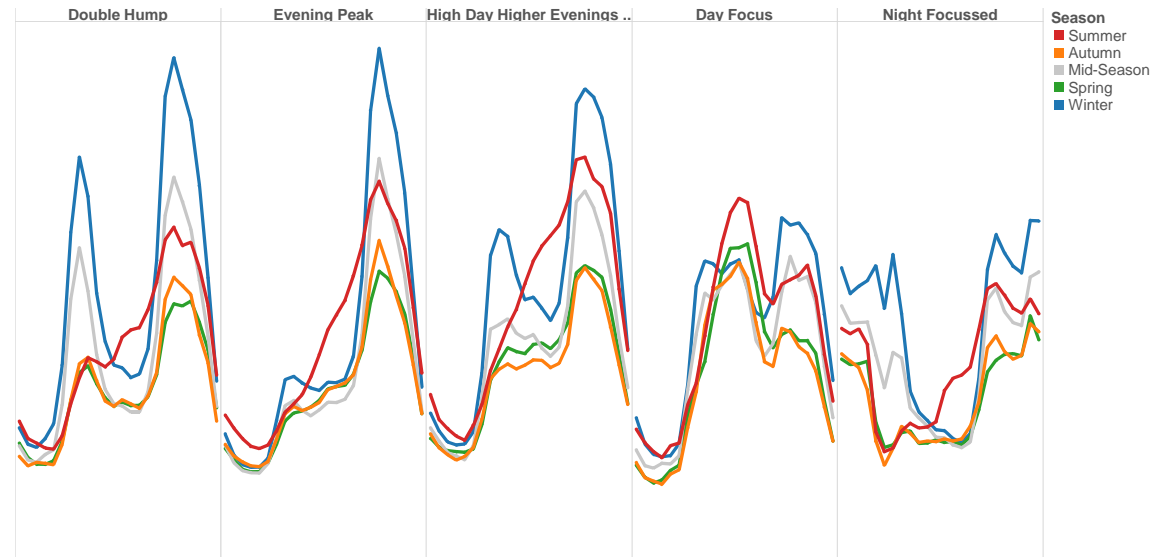
Q: What proportion of household's needs do you want to supply from battery storage?

**A: This is a financial optimisation problem... it really depends.**

**Storing the exported energy is a good starting point – this could be calculated by reading the export meter and compared to the inverter's production and installation date to reach a kWh/day export figure.**

## Sizing: Step 2

- Understanding your Customer's consumption profile
  - High-level (daylight hours consumption) isn't sufficient
  - Seasonal variation influences how much solar generation is captured and how much overflows the batteries... how much \$\$\$ benefits it creates
  - Variation in consumption profiles influences charge/discharge strategies



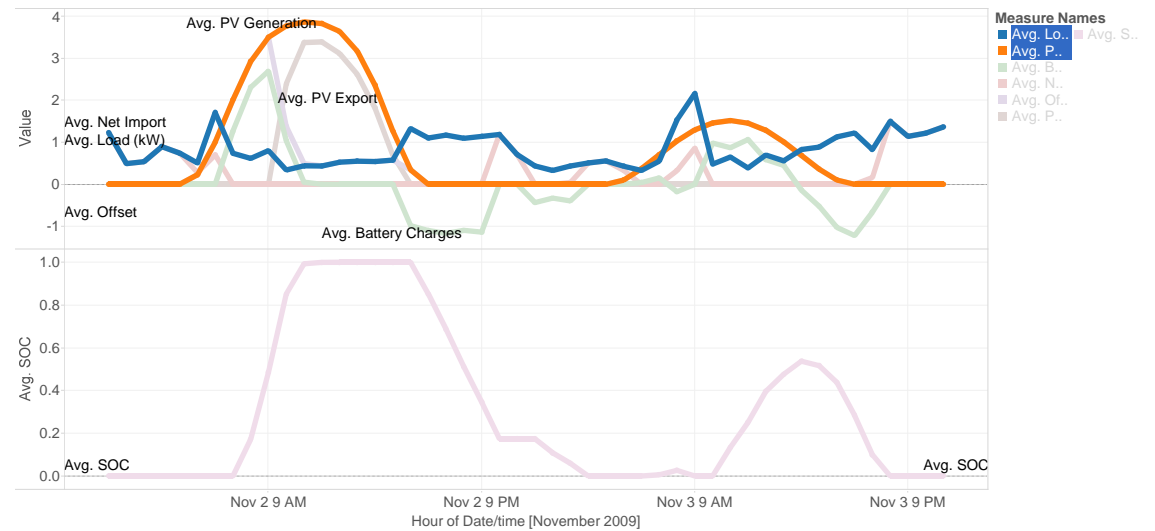
The trend of % of annual consumption for datetime Hour broken down by Peakiness (group). Color shows details about Season. The data is filtered on Customer, which keeps 287 of 300 members. The view is filtered on Peakiness (group), which excludes Consistent.

# Modelling

Assumes household away during the day

Somedays no discharging happens;  
Somedays little charging occurs.

Assumes annual "Blackout avoidance  
benefit" worth 5% of current bill.

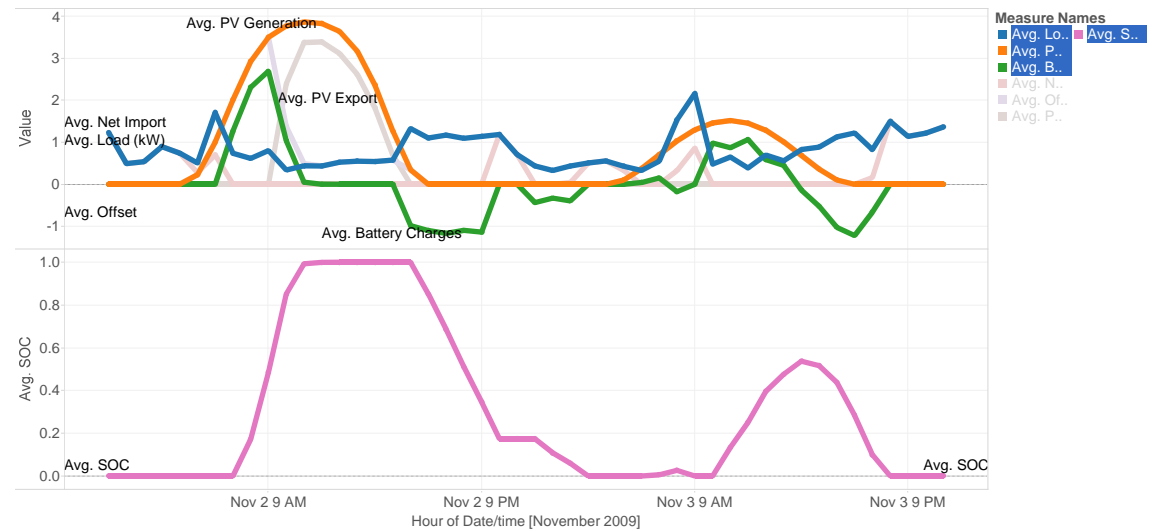


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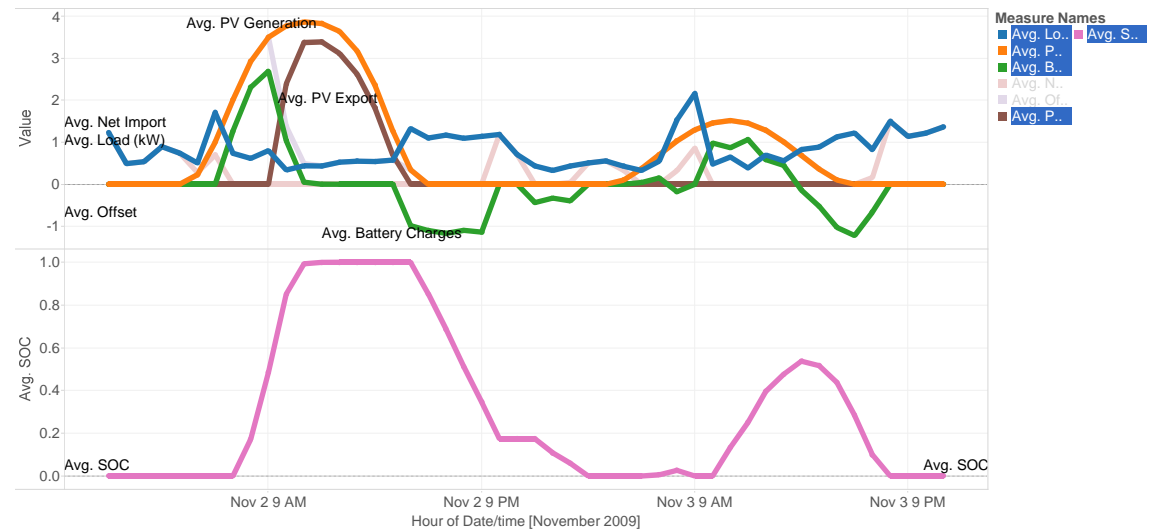


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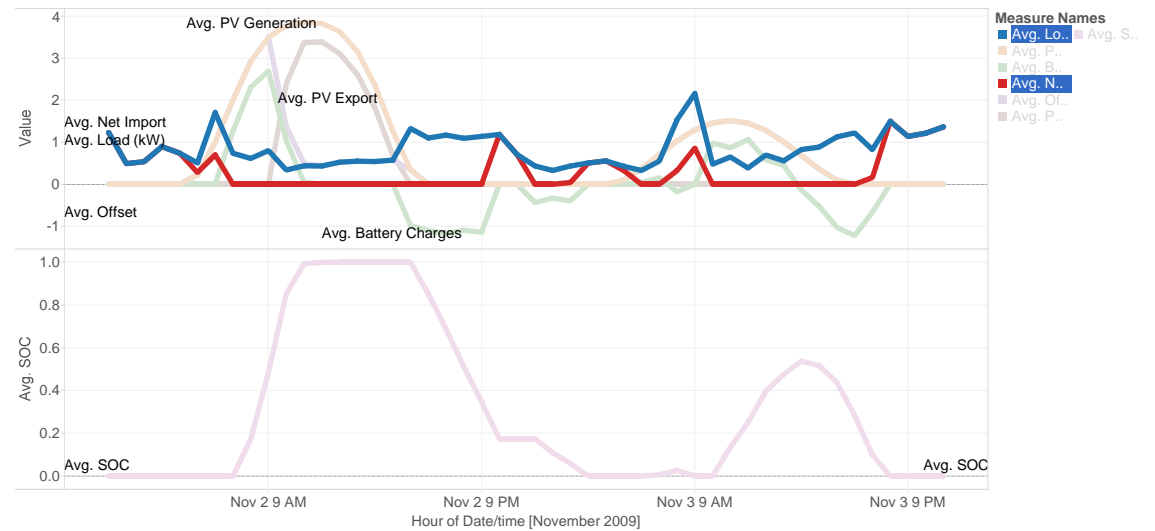


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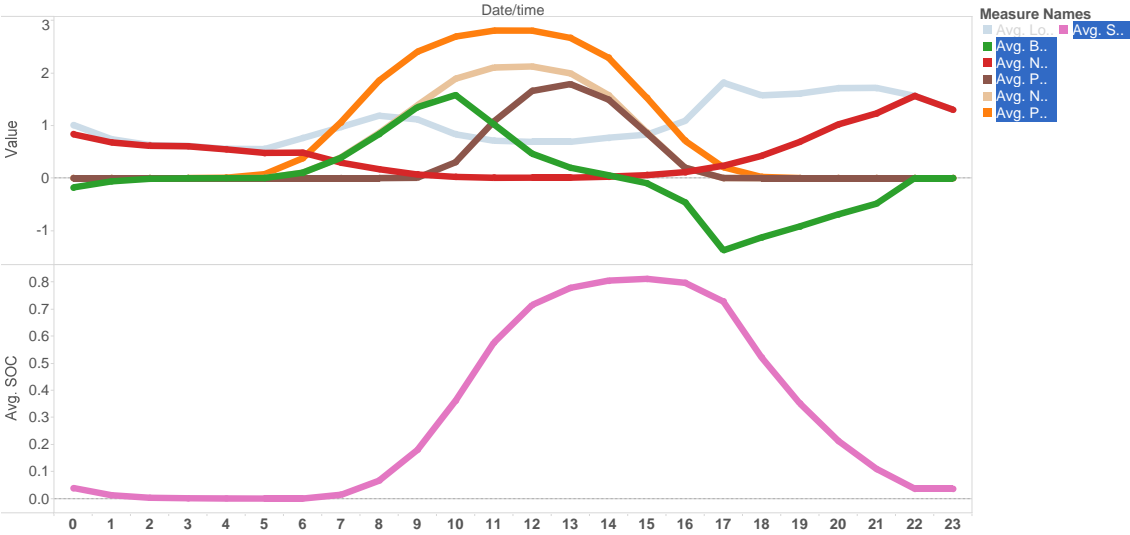
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# Average energy flows

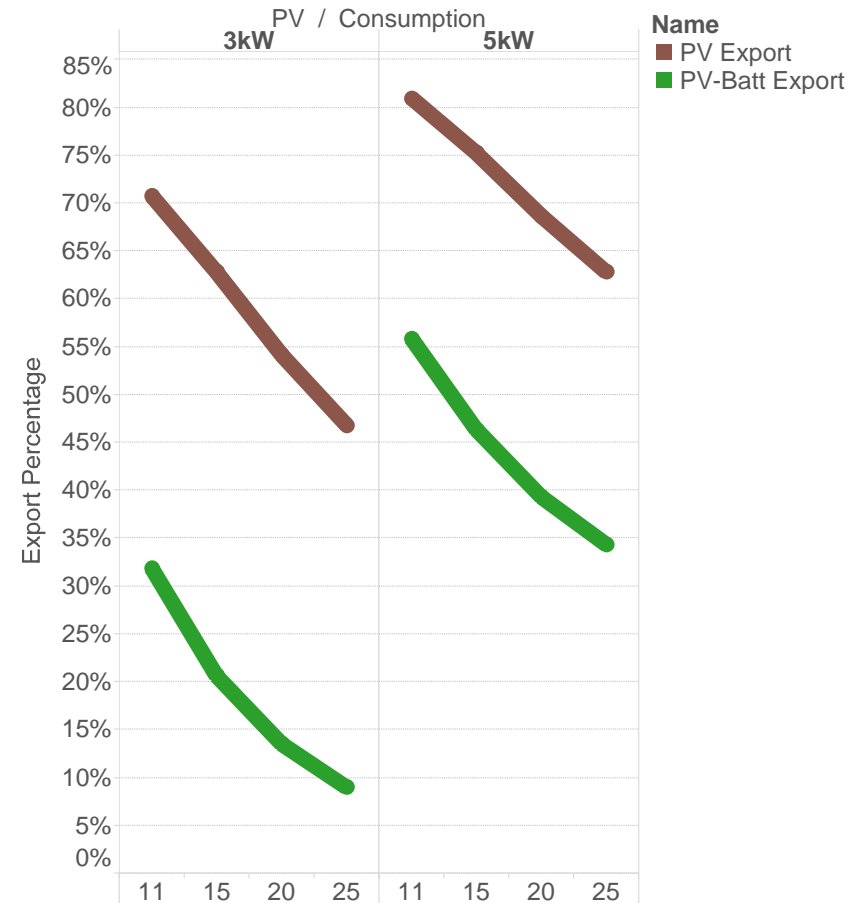


# How much achieved with PV-Batteries?

Reducing export:

- 7kWh of storage drops export by 40% on a 3kW system, and by 25% on a 5kW system.

**RULE OF THUMB (?):** 7kWh of usable storage reduces export by 5kWh/day (for a household away during the day).



# Modelling Payback

## PV only:

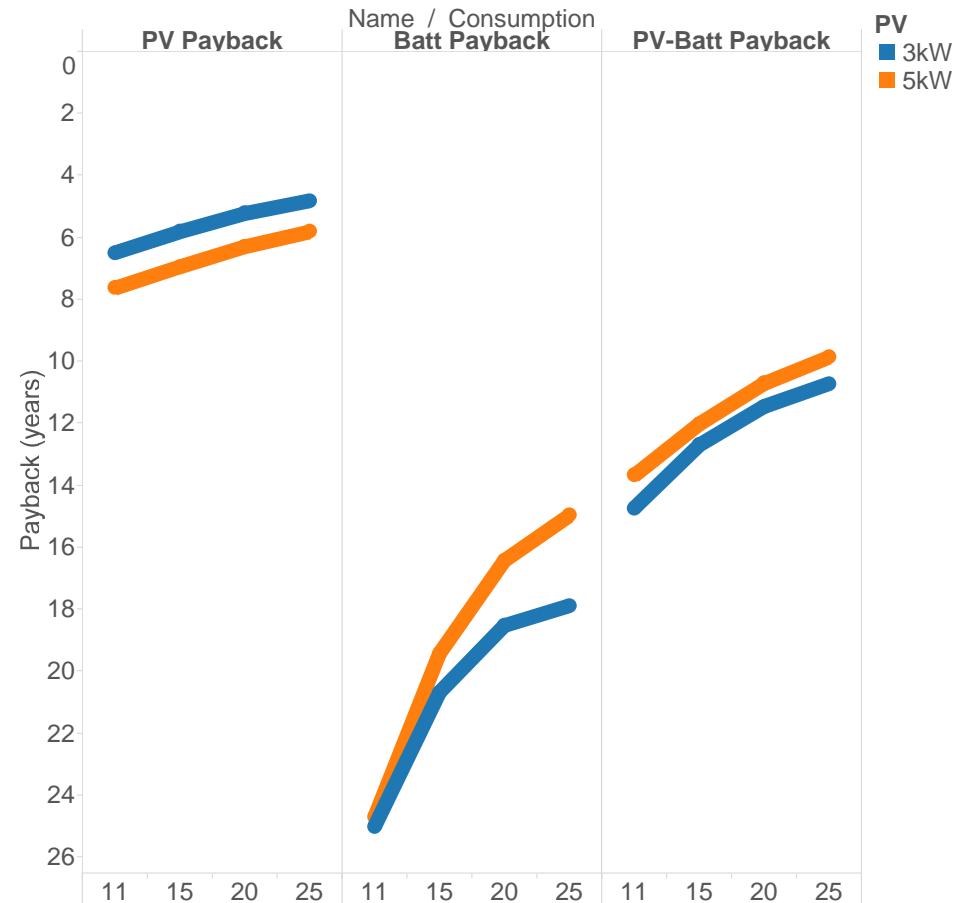
- payback is quicker for smaller systems as lower export
- Payback improves with higher consumption (as lower export)

## Battery only:

- Payback is really poor on low consumption as battery sits idle a lot of the time
- Payback improves with larger consumption but the best it can do is 15 years

## PV-Battery:

- Payback best on high consumers
- Larger systems better (as making greater use of the expensive battery)



## Sensitivity Analysis

Best case basis: 25kWh/day consumption

PV only: 5.8 year payback

Battery only: 15 year payback

Combined: 9.9 year payback; 10.9% IRR

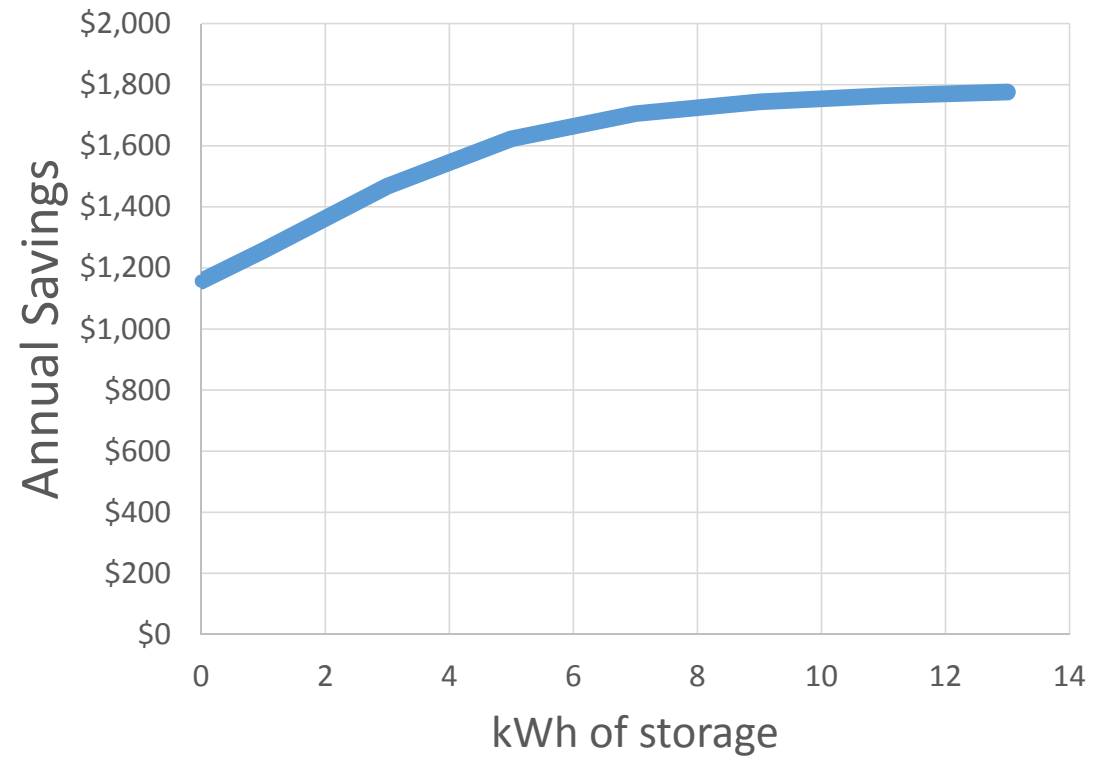
- Moving from Flat-TOU tariffs isn't particularly disadvantageous for Ausgrid.
- If they're home during the day:
  - **Payback falls to 7.6 years**
  - IRR grows to 12.1%
  - Export falls by 6% to 28%
- Its valuable to discharge during the 8-10pm shoulder slot – otherwise exports grow. Pre-discharging in the morning gives a few extra dollars per year, so its
  - Peak-only without other dis-charge: \$1646 with 39% export, 12.7% IRR (14 year life)
  - Peak & Shoulder discharge \$1703 with 29% export. 12.1% IRR (9 year life)
  - Peak-only with morning pre-discharge: \$1641 with 30% export; 11.8% IRR (10 year life)
  - Peak-shoulder with morning discharge: \$1705 with 28% export; 12.1% IRR

## Sensitivity Analysis: additional storage

Diminishing returns of additional storage: As you add storage, you get less and less additional benefit.

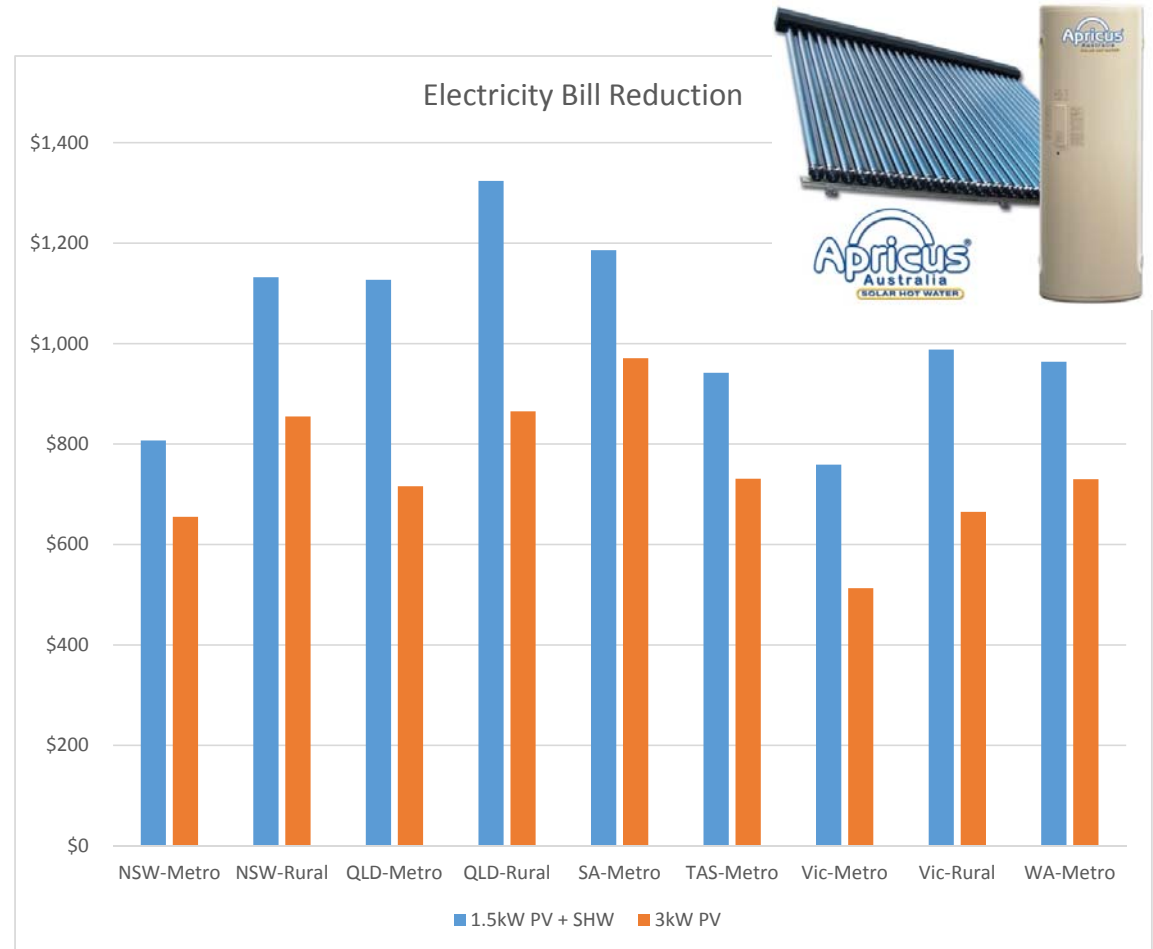
Considering there are economics of scale, there would be some sweet spot... but it will vary by customer.

### Annual Savings vs kWh of Storage



# The other solar energy storage

- SHW commonly has better financials than PV.
  - Often better to buy a SHW unit + 2kW PV than buying 5kW PV.
  - IRR varies by location, water heating backup fuel, and whether HW unit needs replacing.
- Or should I put off-peak HW onto Peak and heat with PV?
  - Instead of export @ 6c/kWh, could heat water and offset 13c/kWh.
  - BUT if I need to boost on cloudy days I might do so at 33c/kWh



# Summary: What to Do?

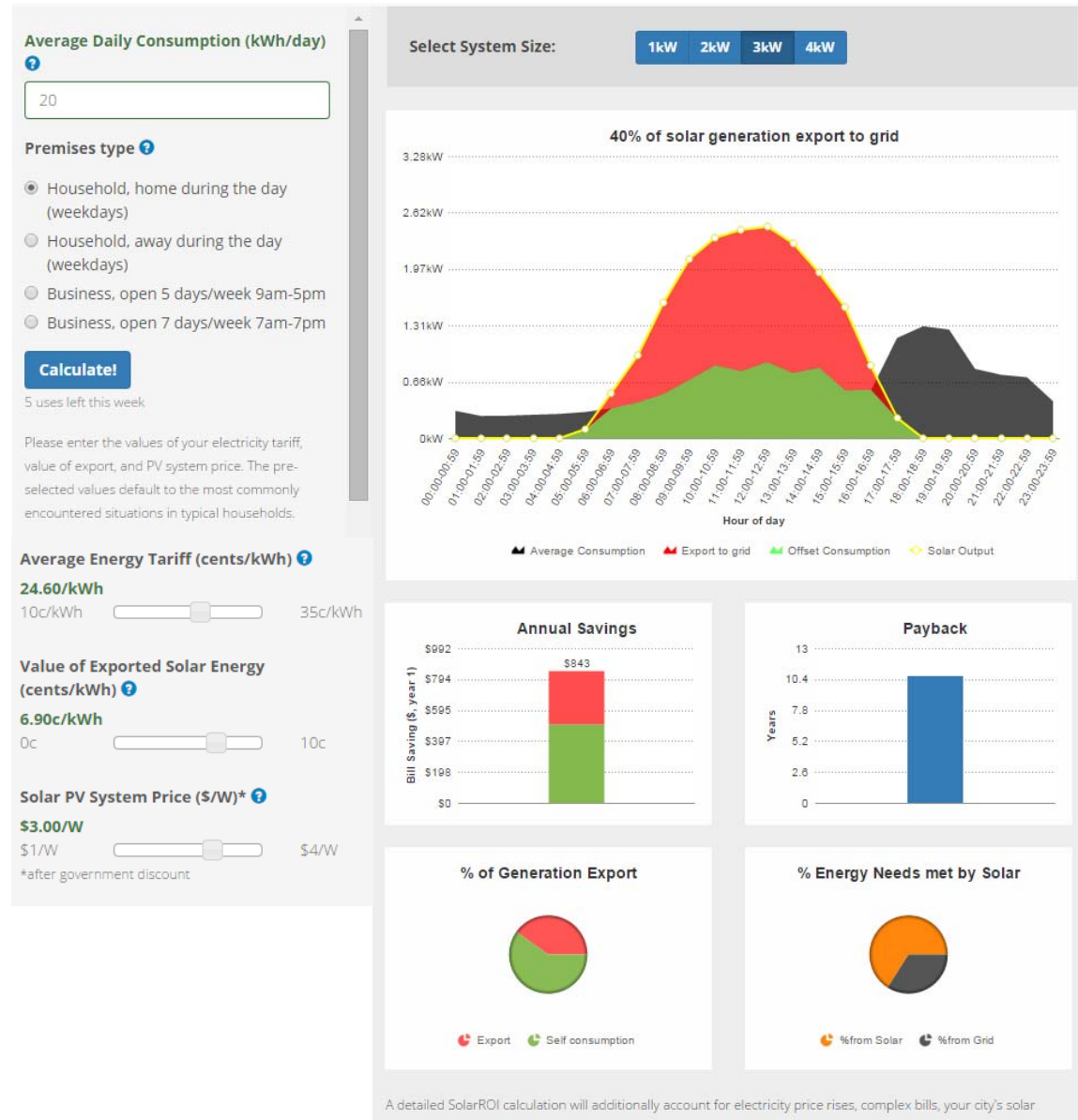
- Yes we have storage: SHW
- Most systems are already oversized and exporting far too much. Another way of looking at it: Crying out for batteries!
- Sell as a bundle with PV; retrofitting to existing PV less financially viable
- Find large consumers of energy
- Opportunity NSW end of FiT 2016 (also Victorian tFiT)
- Wait it out for 2016 – in the meanwhile Transform Your Commercial Profitability with ProfitVoltaics – efficiently target the customers who are easiest to convert and who will pay more for your services.



# Resources

SunWiz's Free Export Calculator

[http://www.pvsell.com.au/dbpage.php?pg=solar\\_export\\_calculator](http://www.pvsell.com.au/dbpage.php?pg=solar_export_calculator)



A detailed SolarROI calculation will additionally account for electricity price rises, complex bills, your city's solar

# Resources

PVsell (Grid-Connect only)  
<http://www.pvsell.com.au> from \$55/month  
 ex GST

Engage SunWiz on your battery backup  
 project – from \$225 ex GST.  
[www.sunwiz.com.au](http://www.sunwiz.com.au)

Buy HOMER energy \$1500-\$3000.  
<http://www.homerenergy.com/>

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**YOUR LOGO**

Your System  
 Name John Smith  
 Address Sunny Way, Green St,  
 NSW 1422

**Project Summary**

System size	5kW
Panels	Great Panels
Inverter	Good Inverter
Features	Best performance Top Efficiency Winning Power
Total Cost	\$8,000
Total Savings	\$1,221

**YOUR LOGO**

**ABOUT YOUR COMPANY**

**Award winning solar experts**  
 We are proudly one of the best solar company there is! We've done heaps of great solar installs all over Australia!

TOP 15 TOP 15 TOP 15

**YOUR LOGO**

**HAPPY CUSTOMERS**

Find out why our customers are so bloody happy. It's because our service is awesome and our products are the best. We rock... If solar companies were any better, they'd be too good.

I am a happy customer

**YOUR LOGO**

**THE NUMBERS**

Here are the PVsell facts and figures. Your project will save you 5x because PVsell have done a lot of hard work to make sure our engine is accurate. That means you can trust our company because we give you figures you can take to the bank!

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Here's everything you need to know about how to proceed with this proposal. You need to act now because this offer is limited. Here are the instructions:

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2. Make a deposit payment
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