



Off-Grid System Sizing

When too big is never big enough



Glen Morris
SolarQuip

Smart Energy Lab

Solar & Storage Training Centre





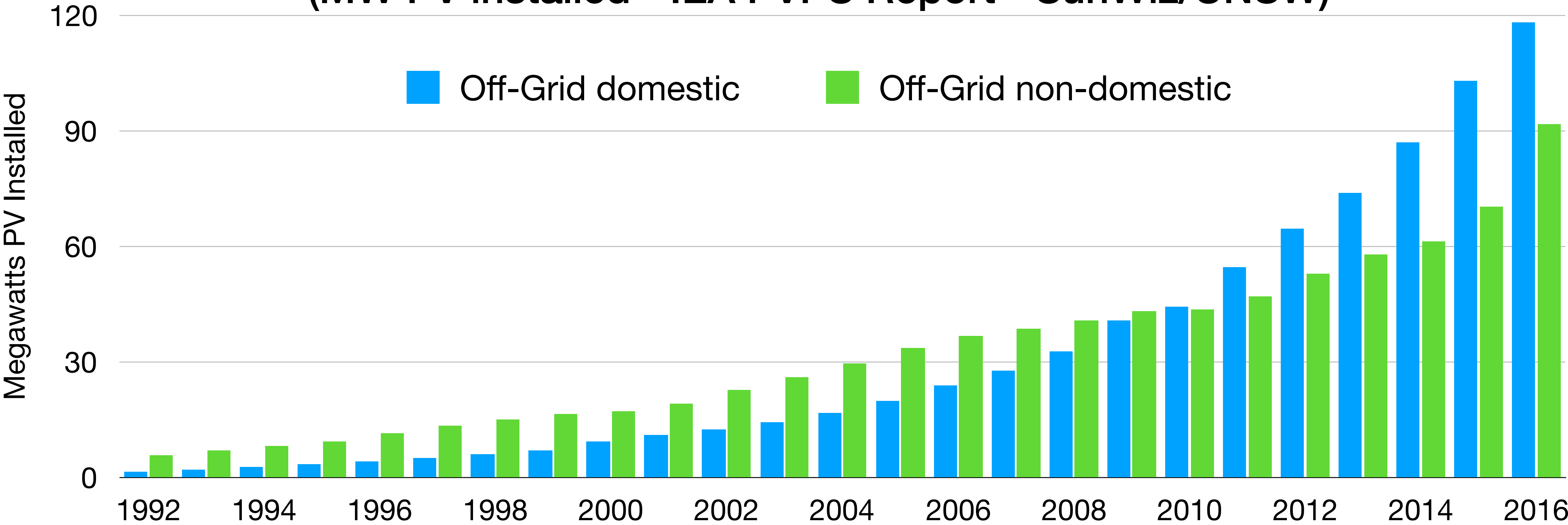
Why Off-Grid?

- no accessible utility grid
- cheaper to build SPS than connect
- total cost of ownership
- energy security
- life-style choice
- leaving the grid
- “preppers” - preparing for the end



Growth of off-grid systems in Australia

(MW PV installed - IEA PVPS Report - SunWiz/UNSW)



Sub-market	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Off-Grid domestic	1,56	2,03	2,6	3,27	4,08	4,97	6,07	6,93	9,22	11,07	12,45	14,28	16,59	19,89	23,88	27,71	32,68	40,76	44,23	54,6	64,6	74	86,9	102,9	118,3
Off-Grid non-domestic	5,76	6,87	8,08	9,38	11,52	13,32	15,08	16,36	17,06	19,17	22,74	26,06	29,64	33,07	36,65	38,73	40,66	43,14	43,57	46,89	53,02	58	61,2	70,4	91,9
Grid-distributed		0,01	0,02	0,03	0,08	0,20	0,85	1,49	2,39	2,80	3,40	4,63	5,41	6,86	9,01	15,04	29,85	101,21	479,34	1268	2276	3070	3871	4578	5329
Grid-central				0,02	0,20	0,21	0,52	0,54	0,54	0,54	0,54	0,66	0,66	0,76	0,76	1,01	1,32	2,53	3,79	7,40	21,5	24	68,5	358,3	445,8
TOTAL (MWp)	7,30	8,90	10,70	12,70	15,70	18,70	22,52	25,32	29,21	33,58	39,13	45,63	52,30	60,58	70,30	82,49	104,5	187,6	570,9	1 77	2415	3225	4087	5109	5986

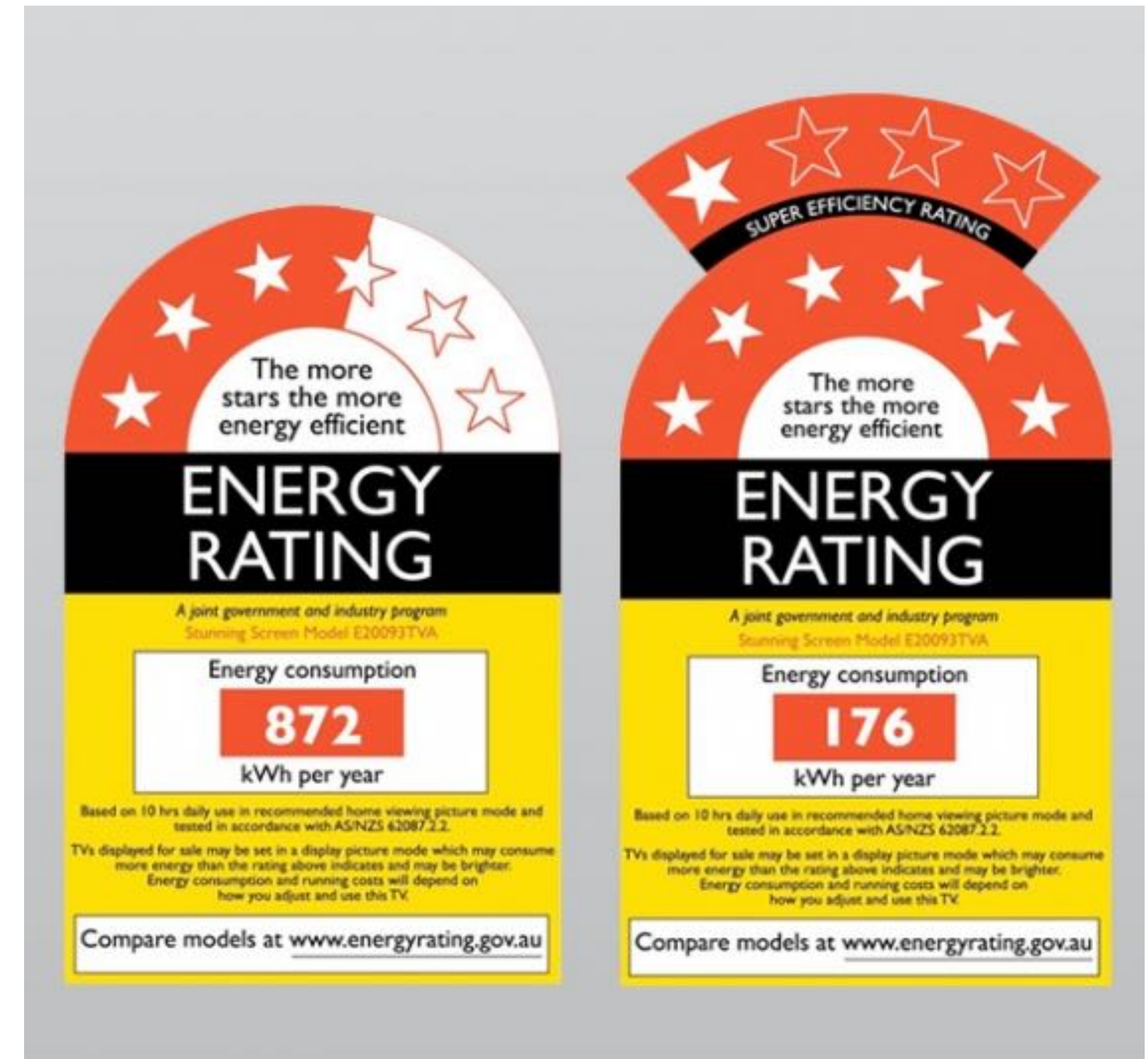
Step 1: client objective

- safe, reliable power
- cost effective (cheaper than grid connection)
- environmentally sustainable
- dislike the power utilities
- pre-purchase 10yrs+ power
- health security (i.e. dialysis machine)



Step 2: energy efficiency

- cost of off-grid system approximately \$2,000-\$4,000/kWh/day of energy required
- use energyrating.gov.au to help select best appliances
- use customer load sheet to identify “problem” appliances (old fridge/old aircon/septic system/water pump/swampy)
- if possible suggest passive solar building design to minimise active heating and cooling.



Step 3: planning

roof layout

cable routing

battery location

switchboard location



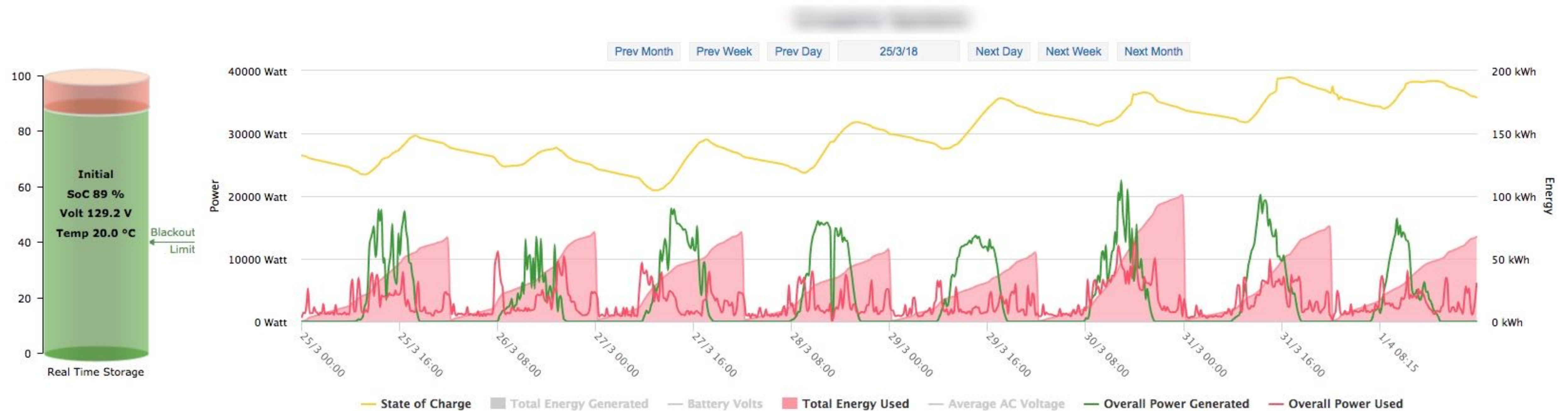
SolarPlus

Step 4: installation



The Green House Effect
Solar & Battery storage systems
Healesville, Victoria

Step 5: post installation monitoring

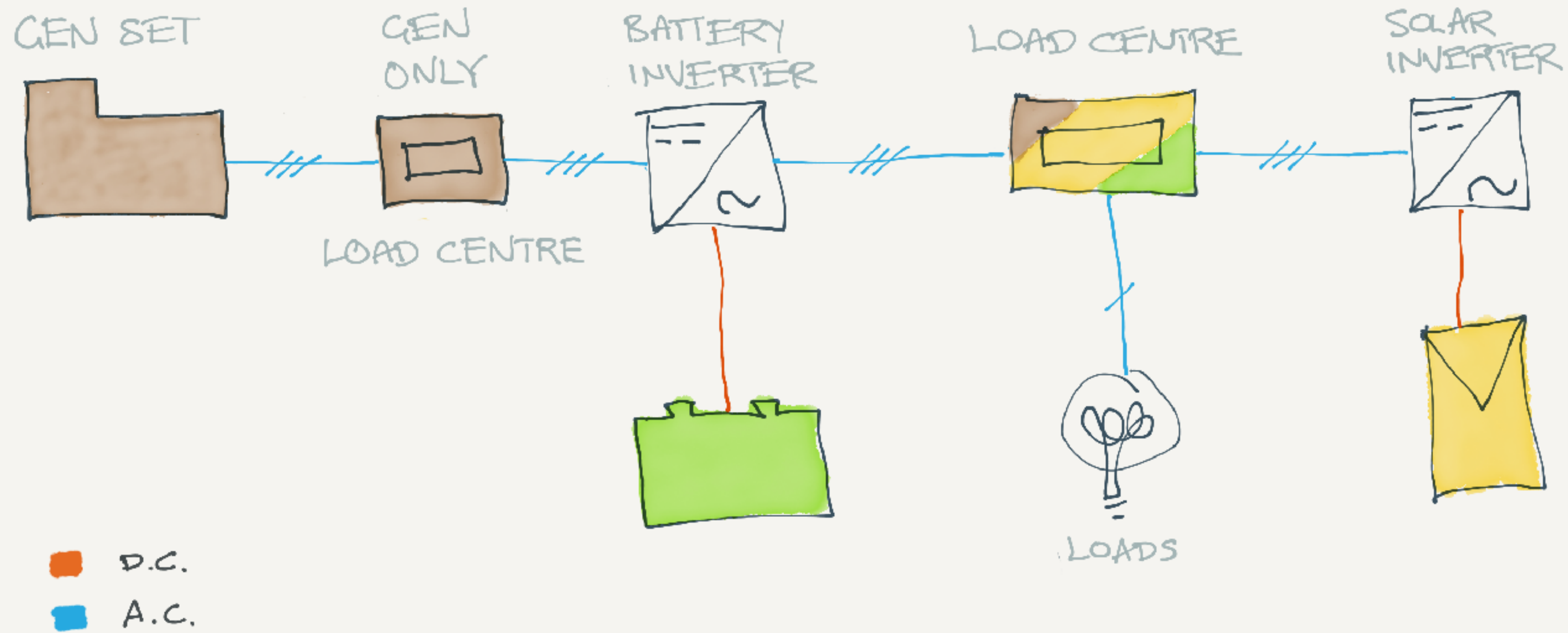


System Configurations

a.c. coupled
d.c. coupled
both

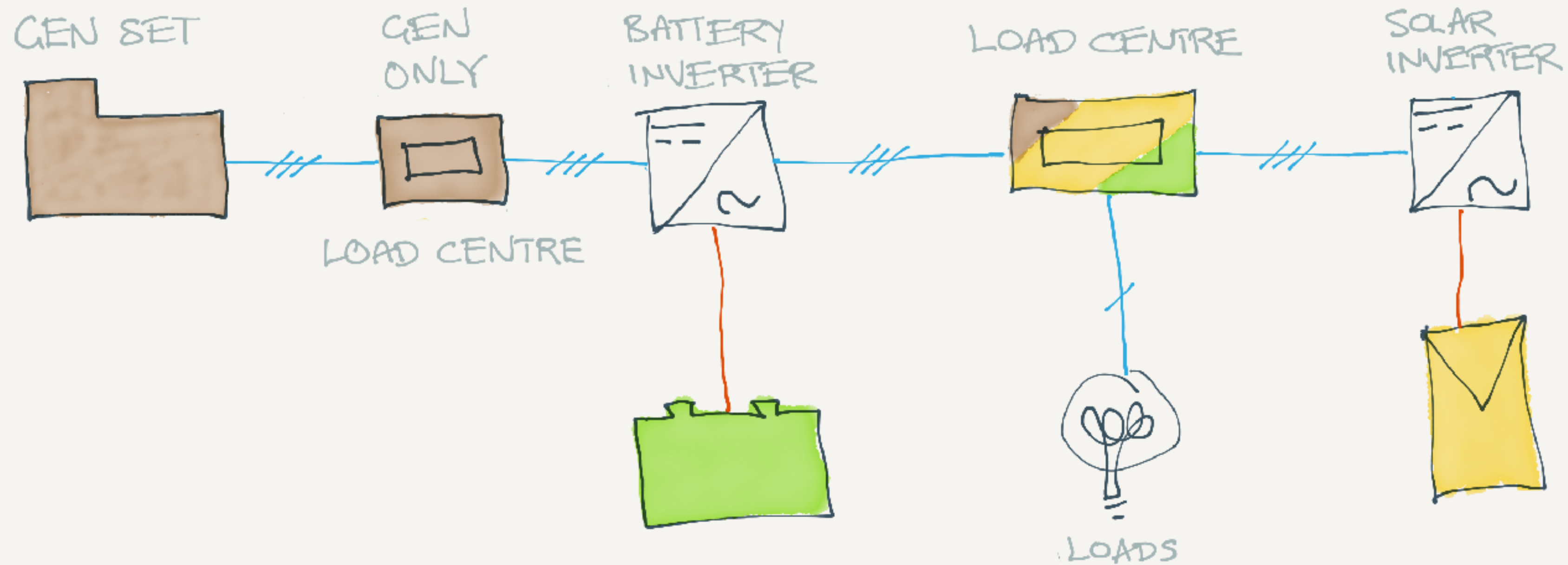


DIESEL + SOLAR + BATTERY HYBRID SYSTEM 1 ϕ or 3 ϕ



NB. SOLAR + BATTERY SYSTEM
OPERATES WITHOUT GENSET

DIESEL + SOLAR + BATTERY HYBRID SYSTEM 1 ϕ or 3 ϕ



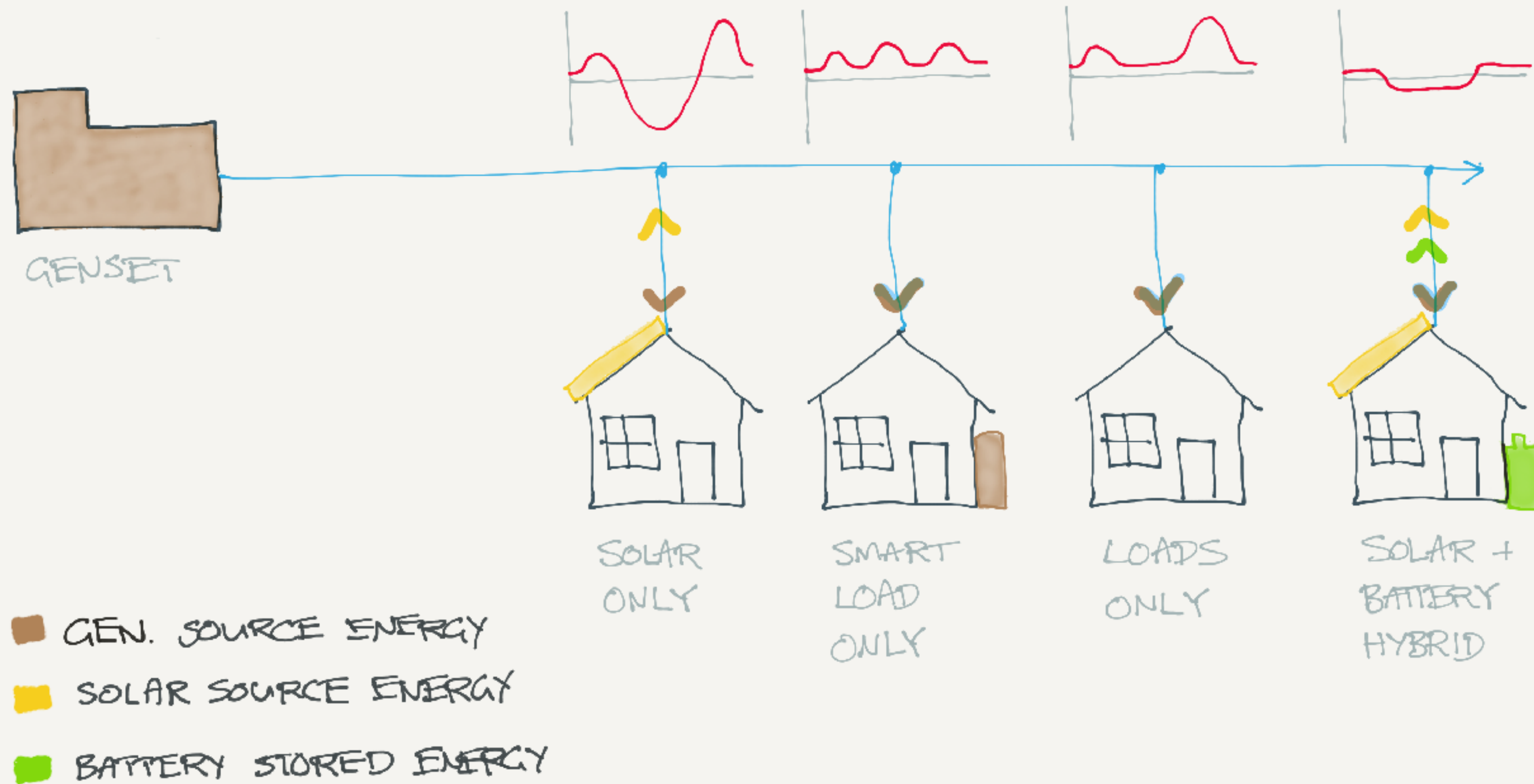
PROS:

genset may be run at near constant load or even intermittently
two independent sources of base load power (gen / battery)

CONS:

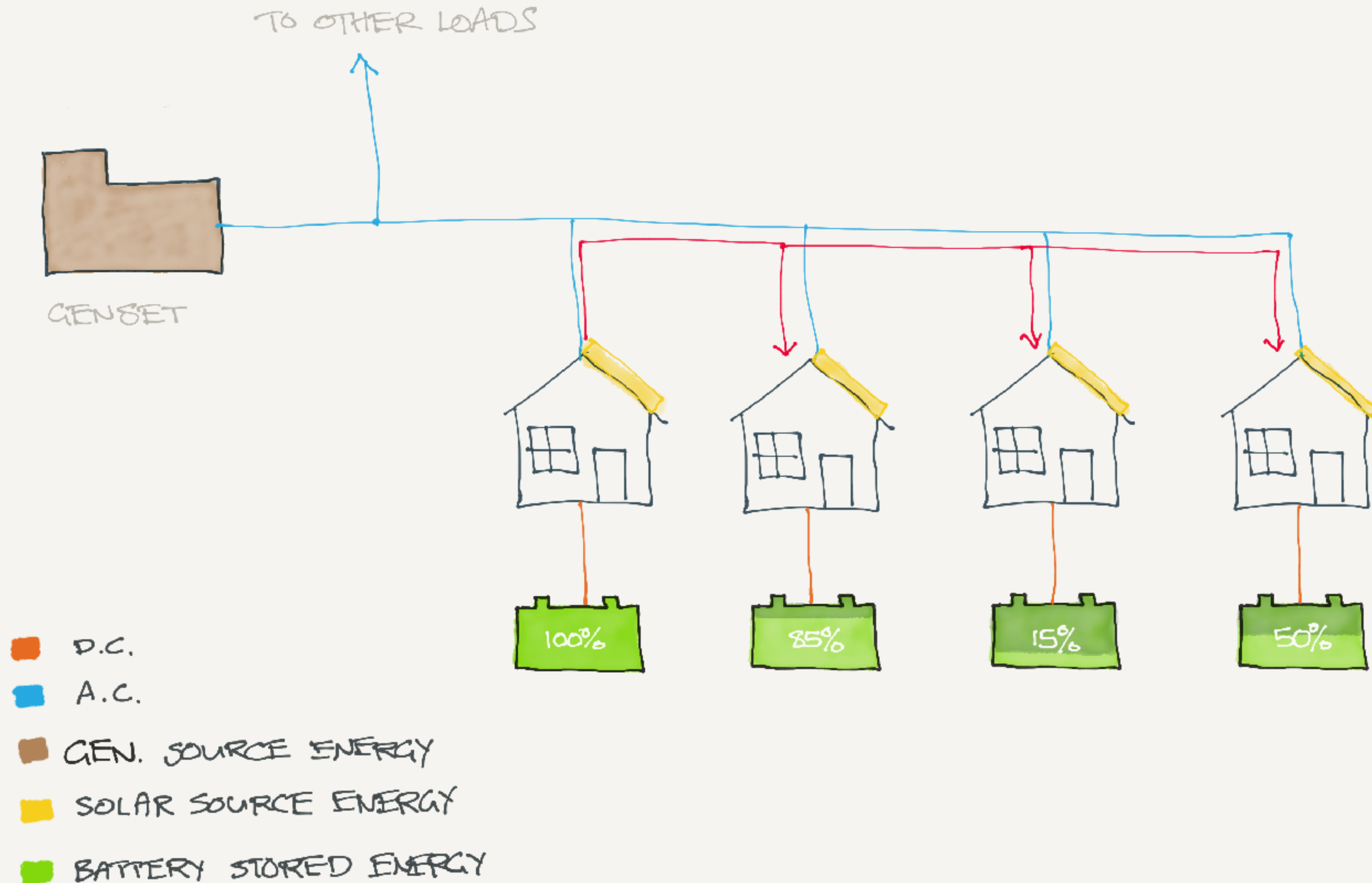
inverter pass-through capacity limits supported loads
requires coordination between generating sources (coms or freq/power ctrl)

VARIOUS LOAD CHARACTERISTICS OF DOMESTIC DWELLINGS



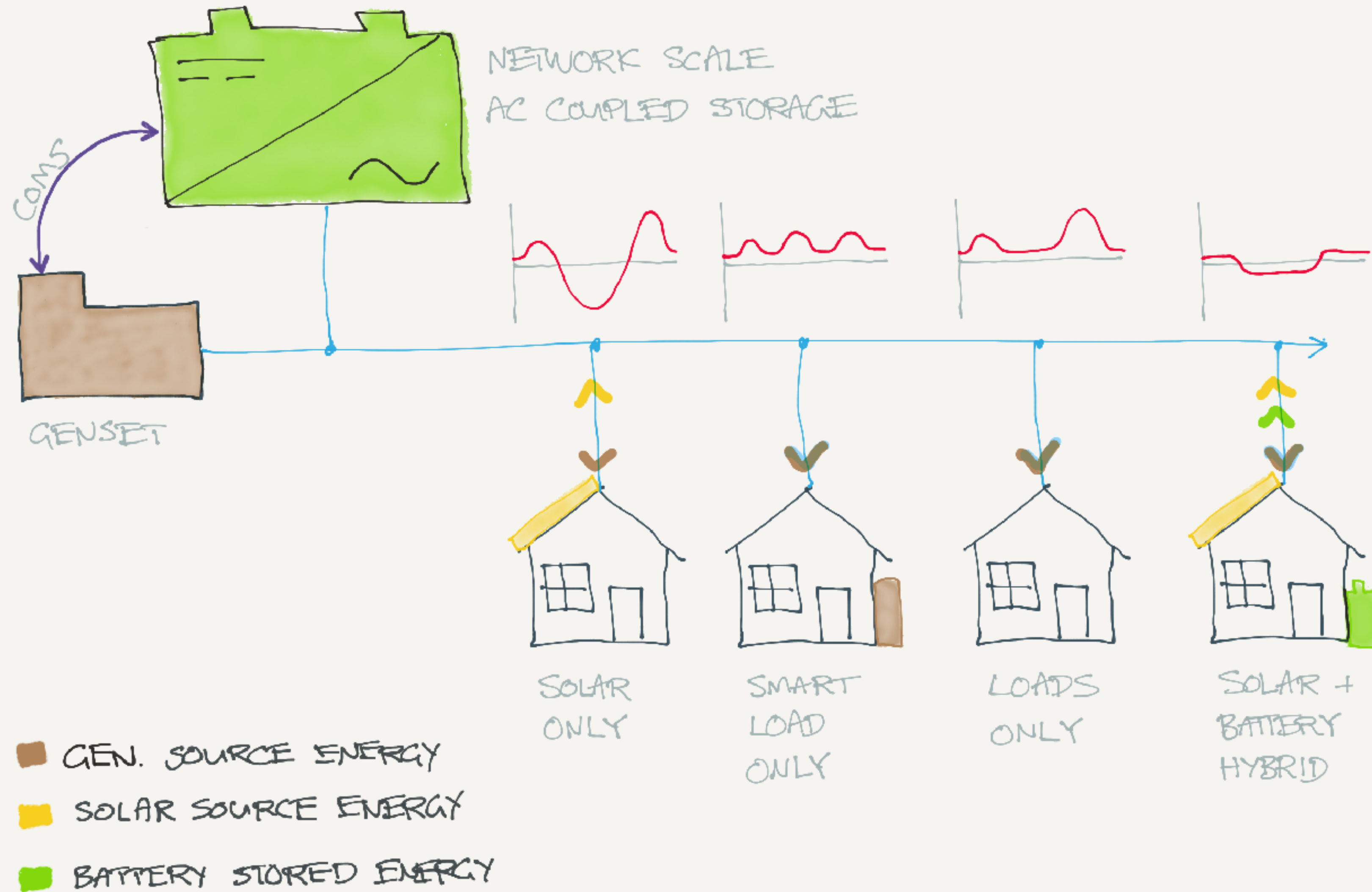
SURPLUS SOLAR ENERGY BALANCED ACROSS MULTIPLE STORAGE

AKA "THE VIRTUAL BATTERY"

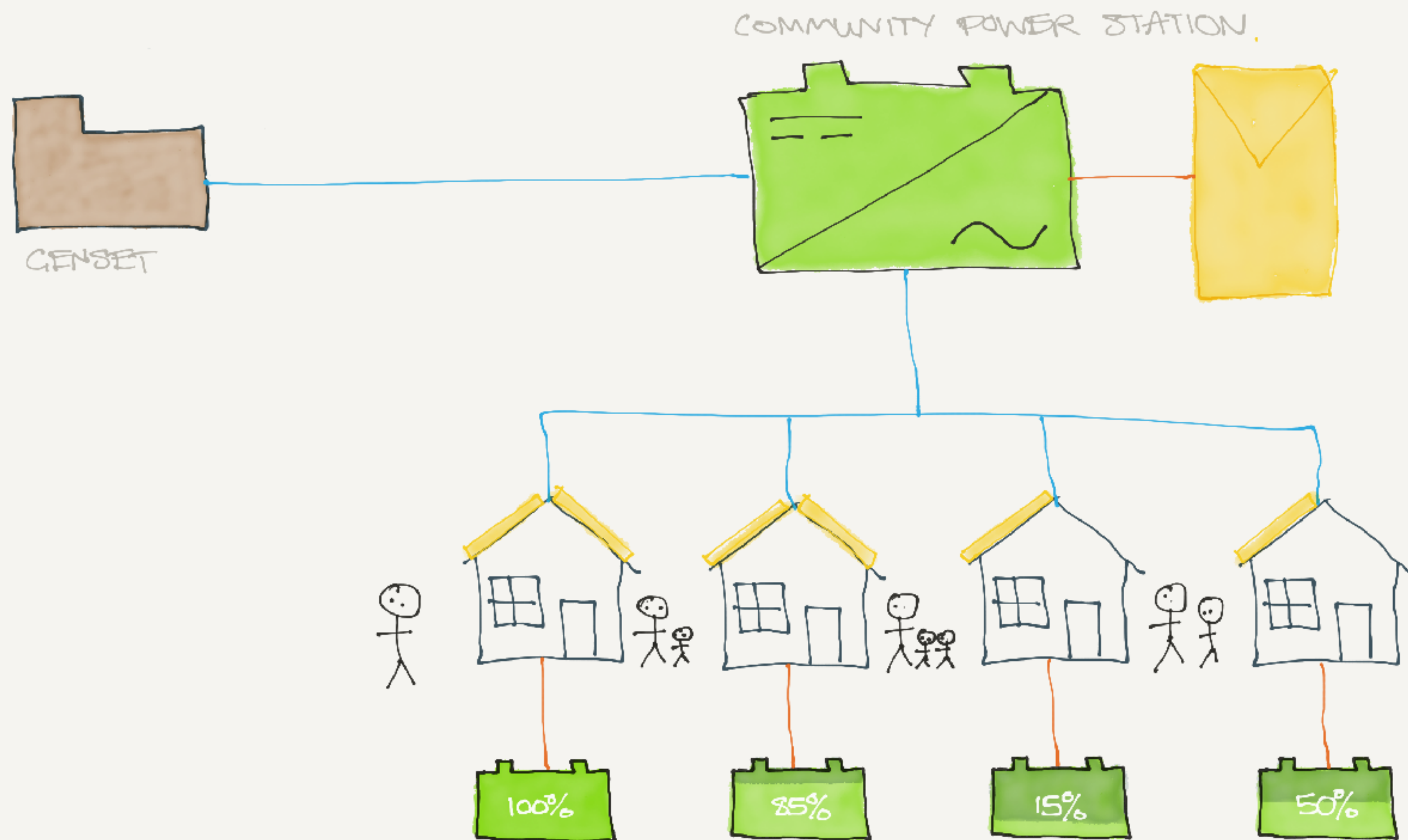


VARIOUS LOAD CHARACTERISTICS OF DOMESTIC DWELLINGS

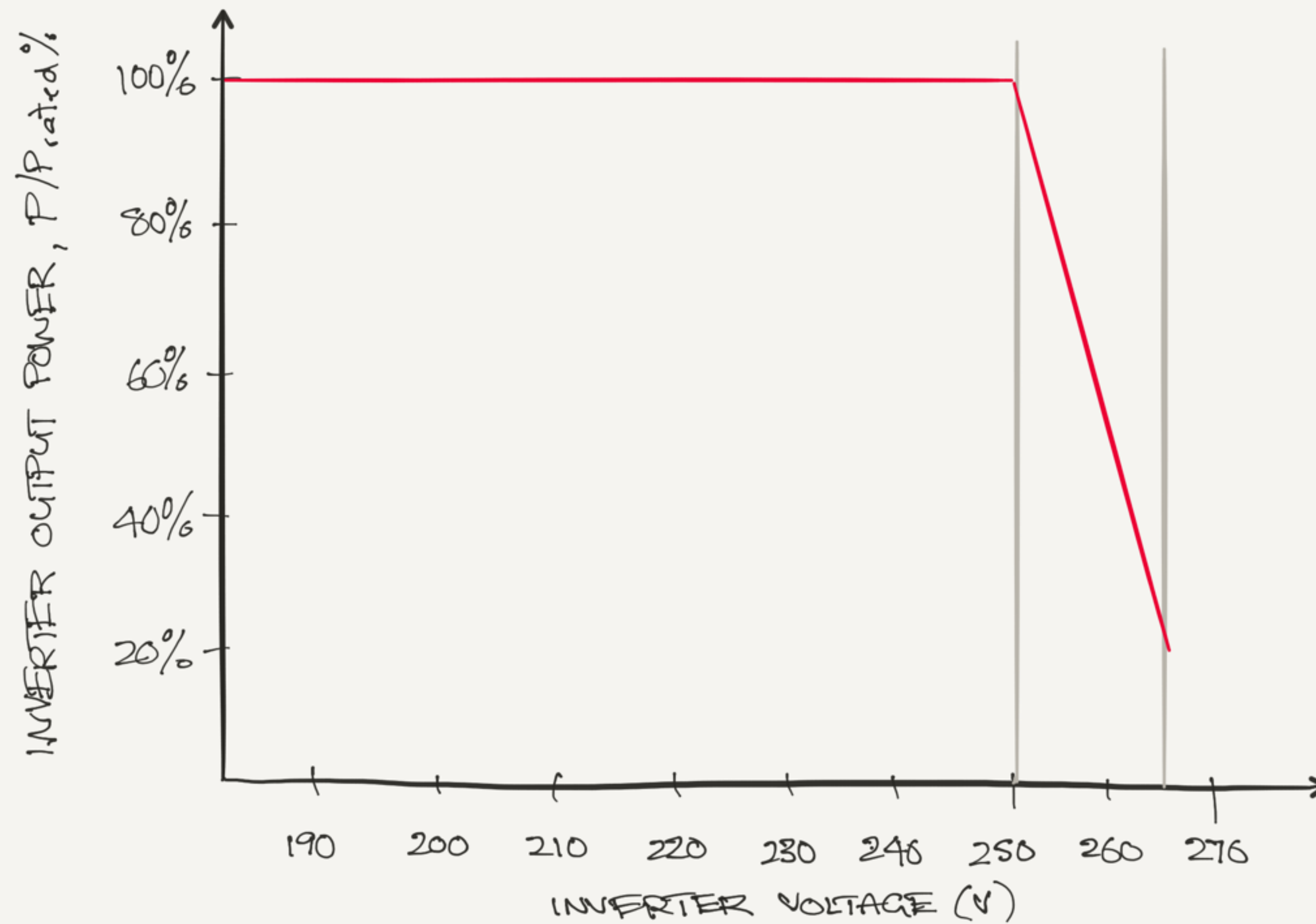
WITH SMOOTHING SUPPLIED BY NETWORK STORAGE



COMMUNITY OWNED POWER GENERATION AND STORAGE SYSTEM
AKA "SOCIALISING ENERGY"

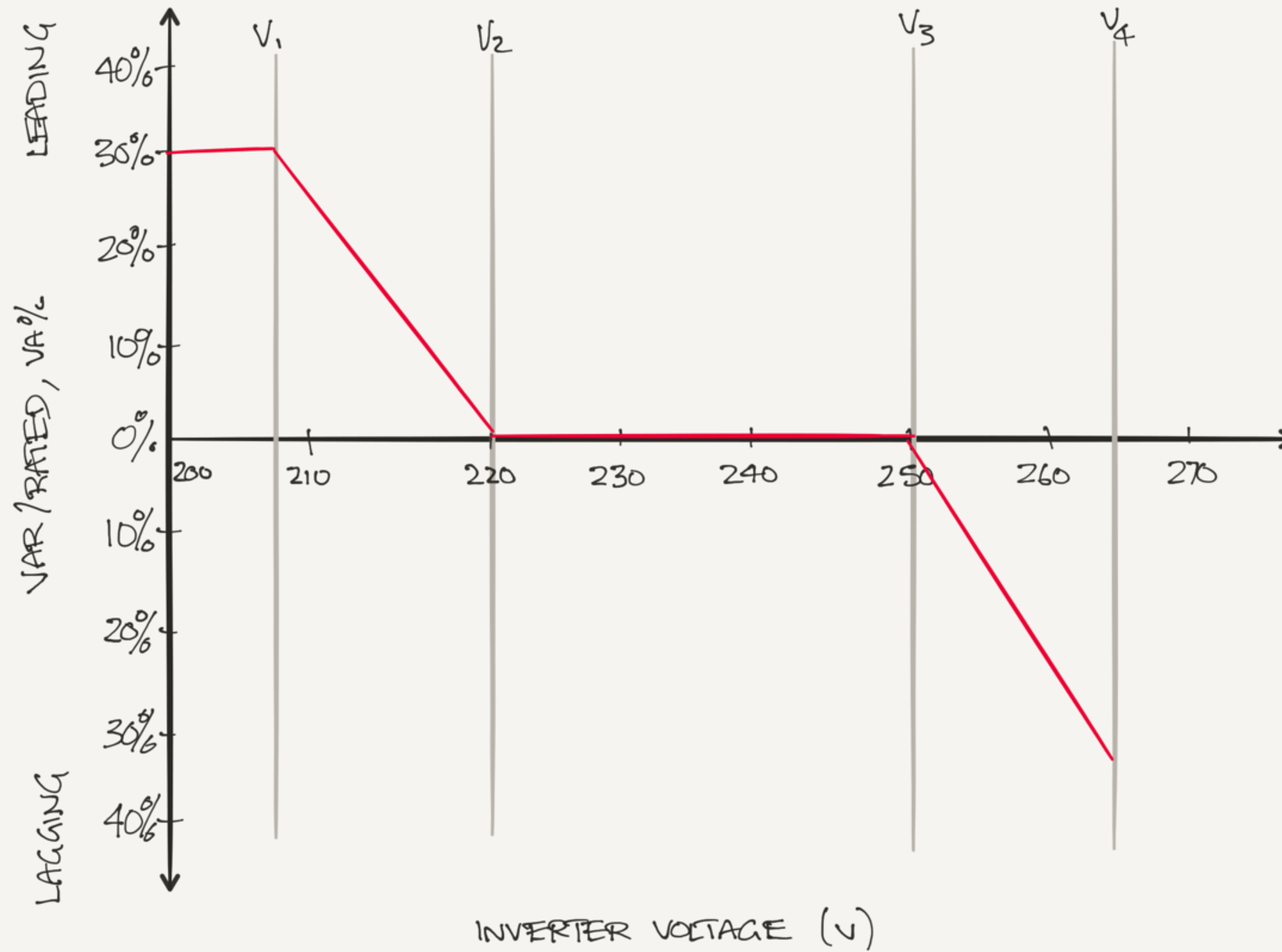


VOLT - WATT RESPONSE MODE (AUSTRALIA)



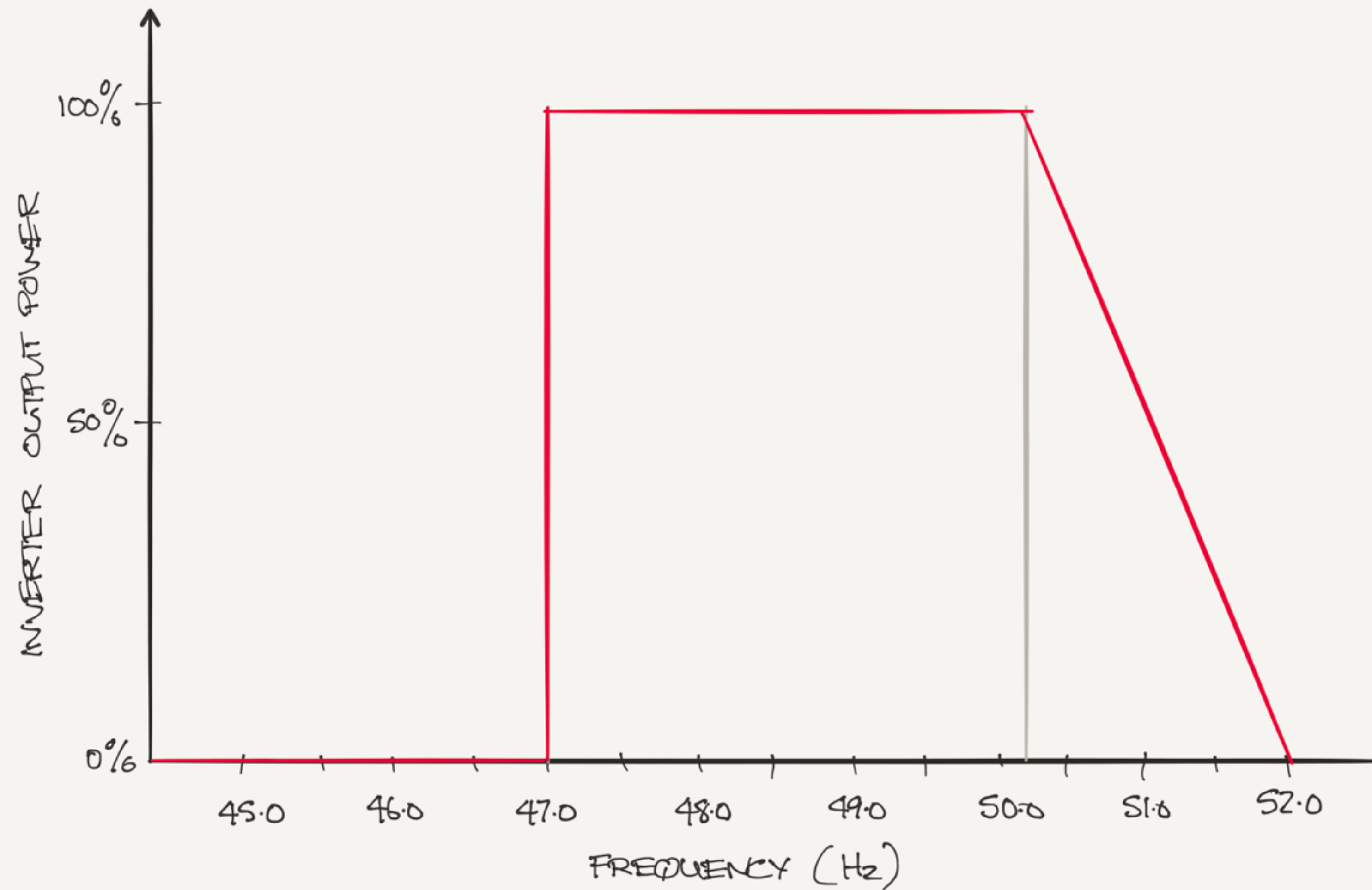
AS/NZS 4777.2:2015 clause 6.3.2.2 Volt-watt response mode

VOLT-VAR RESPONSE MODE



AS/NZS 4777.2:2015 clause 6.3.2.3 Volt-var response mode

POWER-FREQUENCY RESPONSE MODE



AS/NZS 4777.2:2015 clause 7.5.3.1 Response to an increase in frequency

Overview

Performance

Live

Devices

Settings

Users

Alerts

0.000 kWh

TOTAL ENERGY



0.000 kW

CURRENT POWER



0.000 kW

PEAK POWER

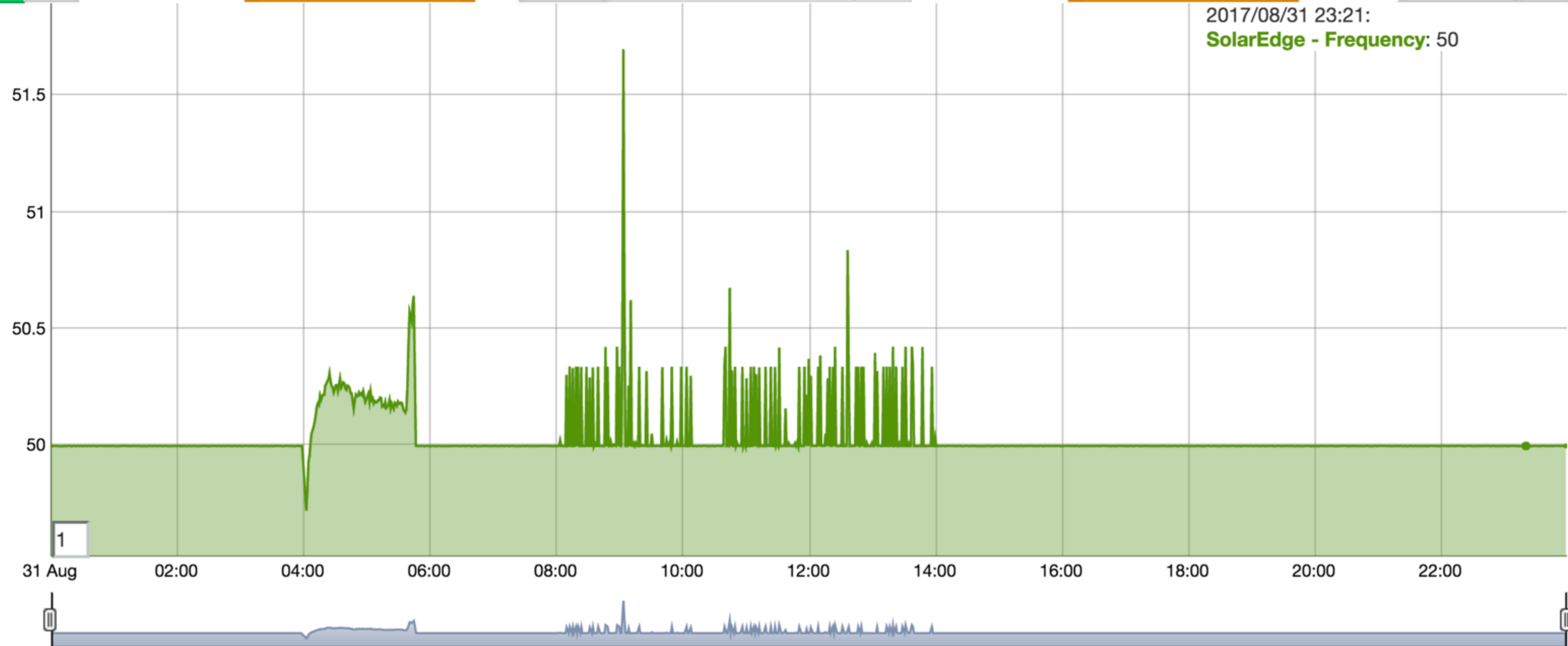


Day ▾

Thu Aug 31 2017



1 of 10 ▾

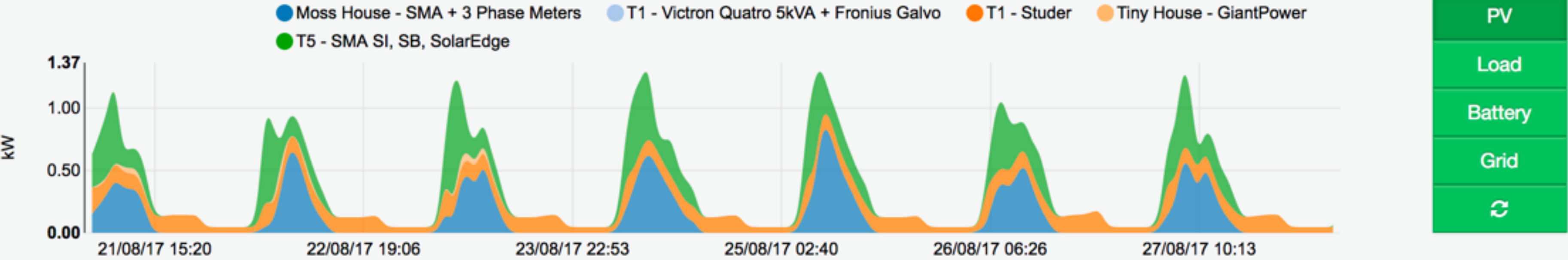


Smart Energy Lab

Portfolios > Smart Energy Lab



- Status
- Map
- Analytics
- Settings
- Users
- DRM Control



SIZING SOLAR PV + BATTERY STORAGE SYSTEM

- A Daily load energy (Wh)
- B Battery system voltage (V)
- C Load sub-system efficiency (eff.)
(wiring, battery, inverter)

D Daily Amp-hour demand (Ah) = $A / B / C$

E PV array size = $\text{Wh (A)} / \text{PSH (actual)} / \text{PV system efficiency} / \text{Load sub-system eff (C)}$

F Battery pack capacity =
$$\frac{\text{Ah demand (D)} \times \text{Days of Autonomy}}{\text{Max. Depth of Discharge}}$$

Smart Loads



vs.



- grid frequency dependent hot water element (power inverse to frequency rise)
- grid frequency controlled circuits (dump loads)
- grid voltage controlled circuits (dump loads)
- solar to hot water diverters

MOORA MOORA COMMUNITY



Sharing energy since 1973 (microgrid/off-grid)



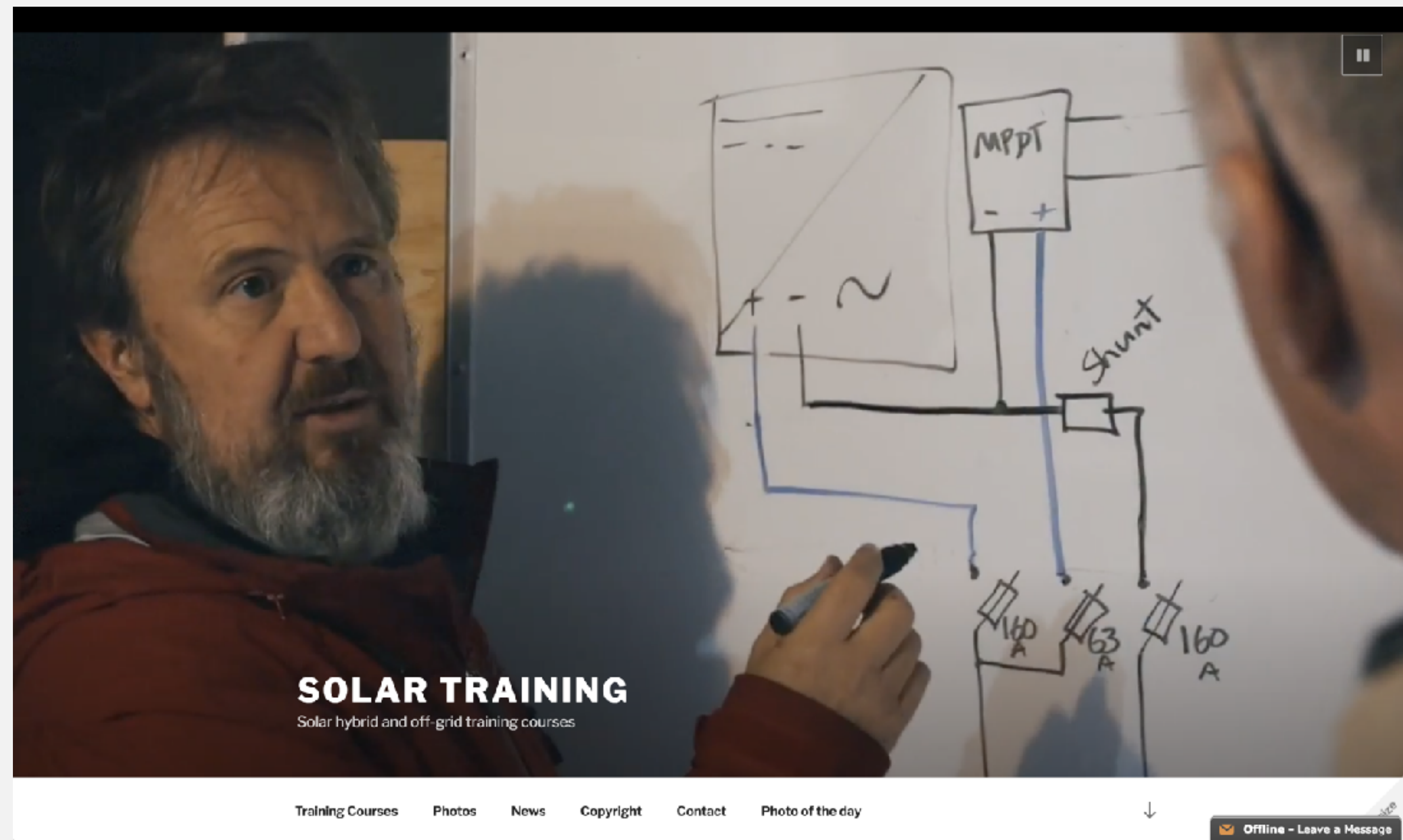
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<http://cleanenergy.org.au> - blog

<http://solarquip.com/> - training courses

<http://smartenergylab.com.au> - the “Lab”