Thinking about home energy storage

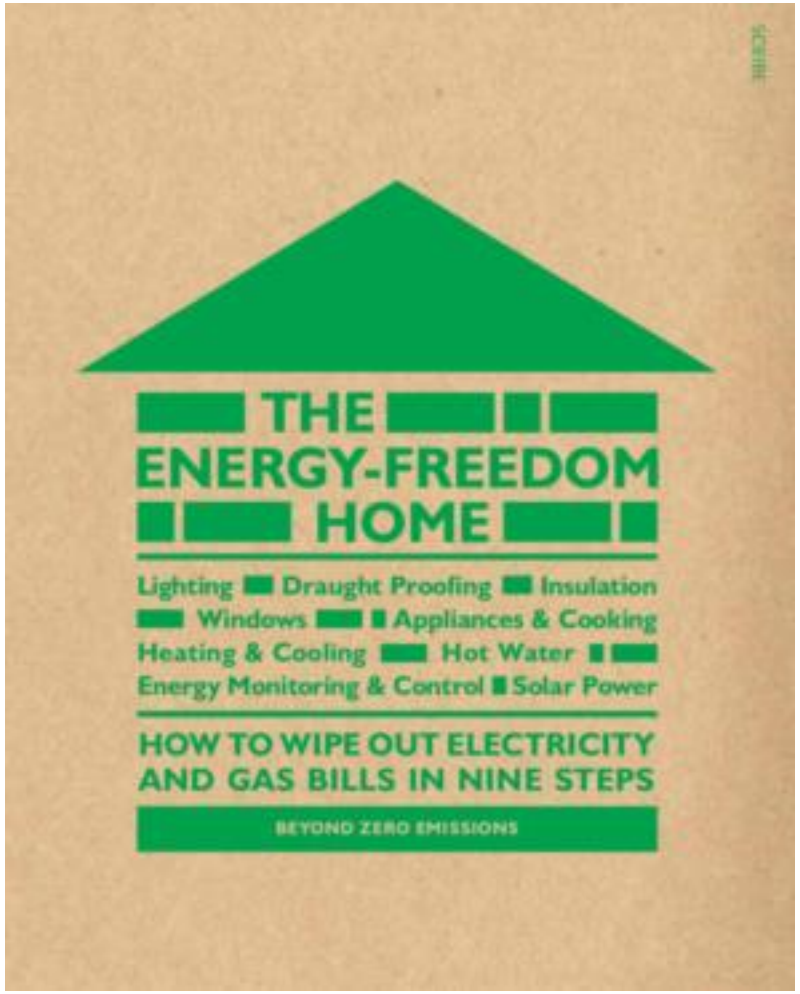
Richard Keech

Motivations for home energy storage

- Environmental / altruistic
  “I don’t want to buy polluting grid power”
  “I want to support clean tech”
  “It will be good for the grid”
- Financial
  “I don’t want to buy expensive grid power”
  “It will save me money”
- Remote / necessity
  “Grid – what grid?”
- Reliability / independence / control
  “I don’t trust the grid”
- Bling / gadget
  “Shiny Powerwall. Mmmm. Shiny.”
- Revenge
  “!*#$! the power company”

Context

- Priority #1: Reduce demand and disconnect from gas
- Priority #2: Generate your own energy
- (net-energy positive)
- Priority #3: Store your own energy
- *ie* get your house in order first



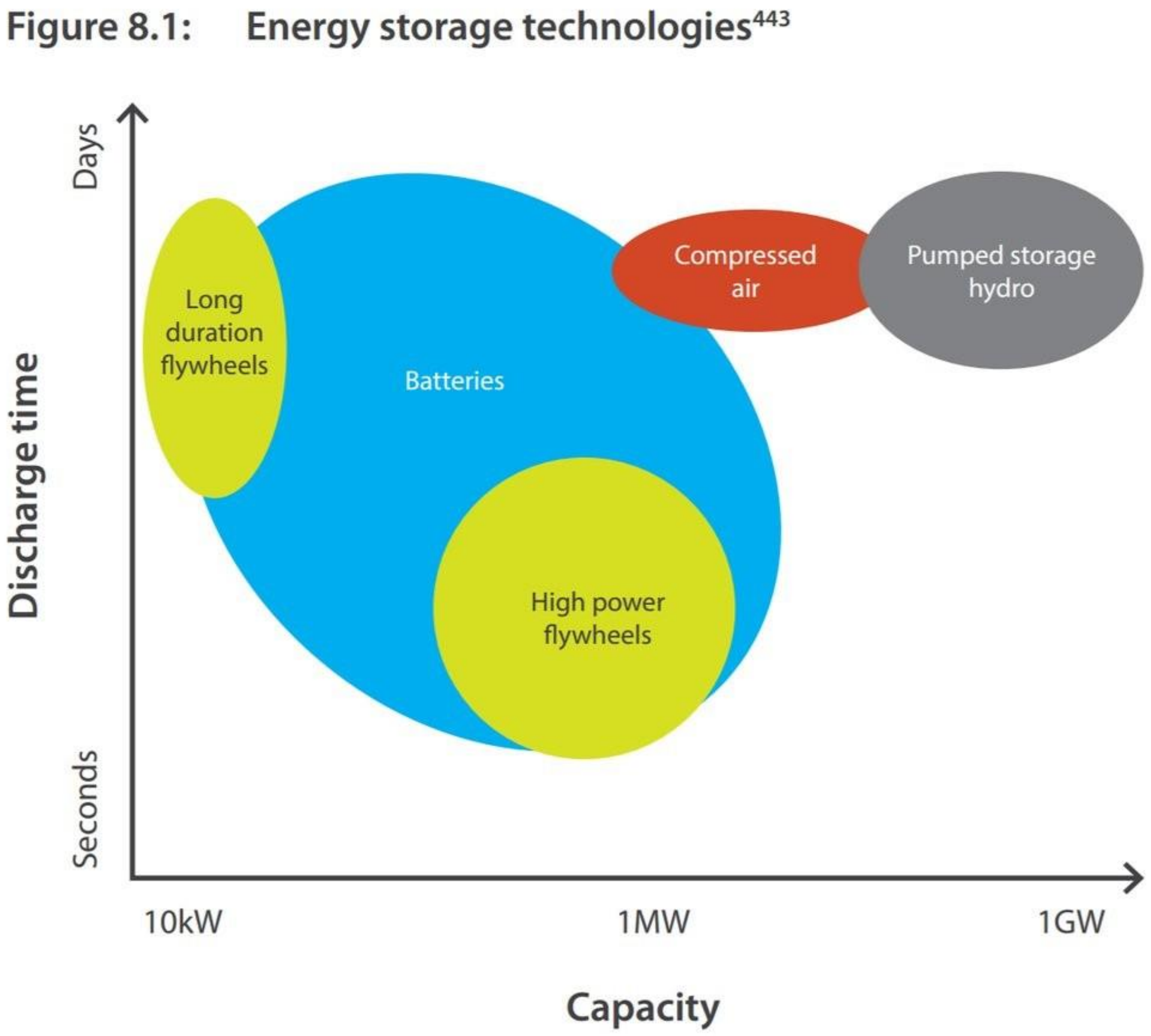
NEWENERGY Thinking

Terminology

- In front of the meter / behind the meter
- Cell
- State of charge
- Capacity (kWh)
- Power (kW)
- Charge / discharge
- Depth of discharge
- Cycles
- Round-trip efficiency
- Battery inverter
- Hybrid solar system
- Arbitrage

NEWENERGY Thinking

Energy storage technologies



Source: Finkel review, 2018 – Figure 8.1

Changing role of the grid

When a home becomes **net-energy positive**

the role of the grid changes *from* an **energy supply system**

to an **energy sharing system**.

On-grid or off-grid?

- *Opinion*: Going off-grid in grid-connected areas is misguided
- Practical implications:
  - off-grid equals having capacity to cope with the worst-case winter week.
  - therefore 51/52 weeks of excess capacity…
  - with no way to sell your excess.
  - serious off-grid systems usually have an auto-start petrol generator.

NEWENERGY Thinking

On-grid or off-grid?

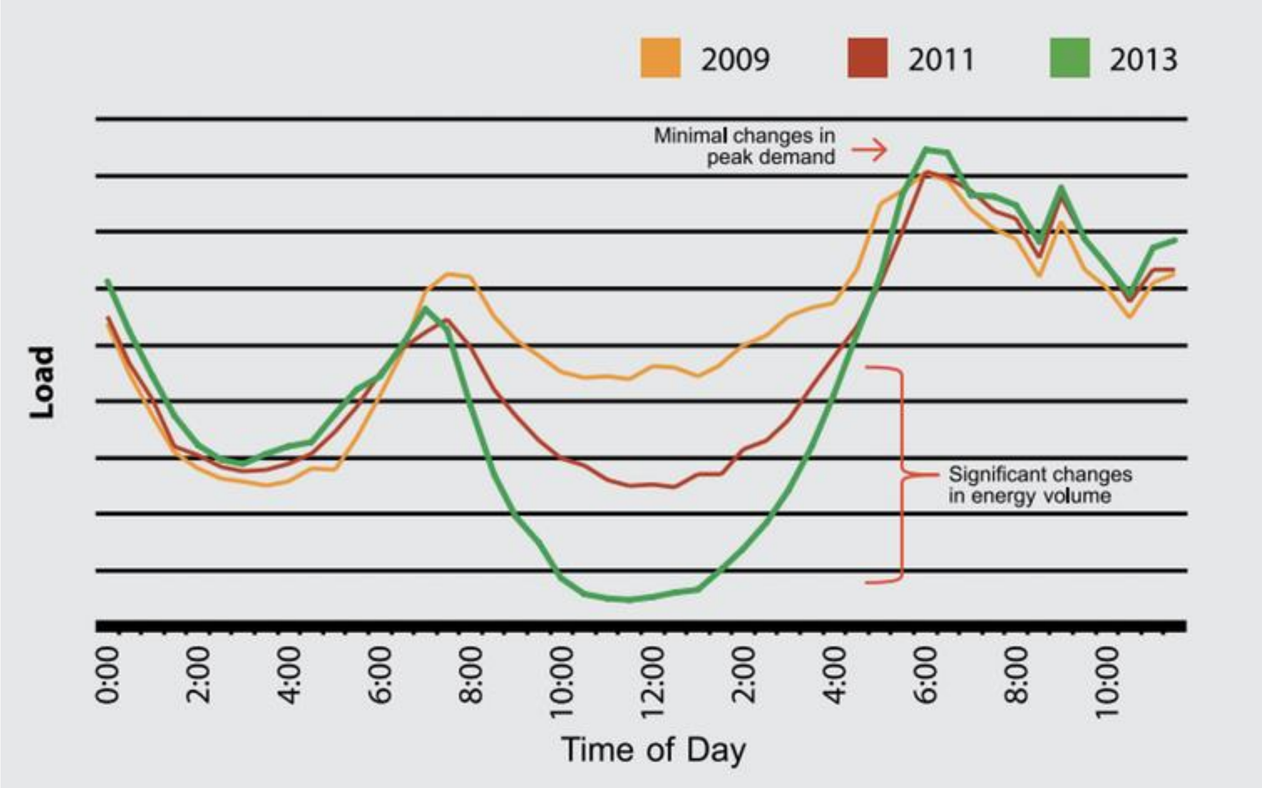
- Big-picture implications of off-grid homes:
  - fewer people supporting fixed costs of the grid
  - risk of a death spiral
  - equity issues
- The grid is a public good – support it.

NEWENERGY Thinking

Batteries and the grid

- The duck curve.

- Batteries can flatten the curve.



- The grid perhaps gains more from home batteries than do households?

NEWENERGY Thinking

Graph: Energy Networks Association https://theconversation.com/slash-australians-power-bills-by-beheading-a-duck-at-night-27234

Energy storage:
Different things for different people

- for **grid**:
  - Voltage and frequency stabilisation
  - Wholesale price stabilisation
- for **commercial**:
  - Reduce peak demand (power, not energy)
- for **home**:
  - Deferred solar consumption (energy, not power)
  - Failsafe backup (maybe)

Refer https://www.youtube.com/watch?v=JPuGE5QOwwU at 10min

NEWENERGY Thinking

Cell technologies / chemistries

- Lead-acid
- Lithium-ion
- Flow batteries
- Aqueous
- Sodium Nickel
- others

NEWENERGY Thinking

Technology: Lead-acid batteries

- Legacy tech (patented 1859)
- Typically seen as 12V, 24V, 48V
- Mature technology
- Very heavy (poor energy density)
- Emit H_2 gas during late part of charge cycle
- Doesn't like partial state of charge
  - Fussy charge cycle to avoid damaging cells
- Real usable capacity << nominal capacity
- Cycles: thousands
- Hybrid Lead-acid / capacitor (CSIRO, Ecoult)

NEWENERGY Thinking

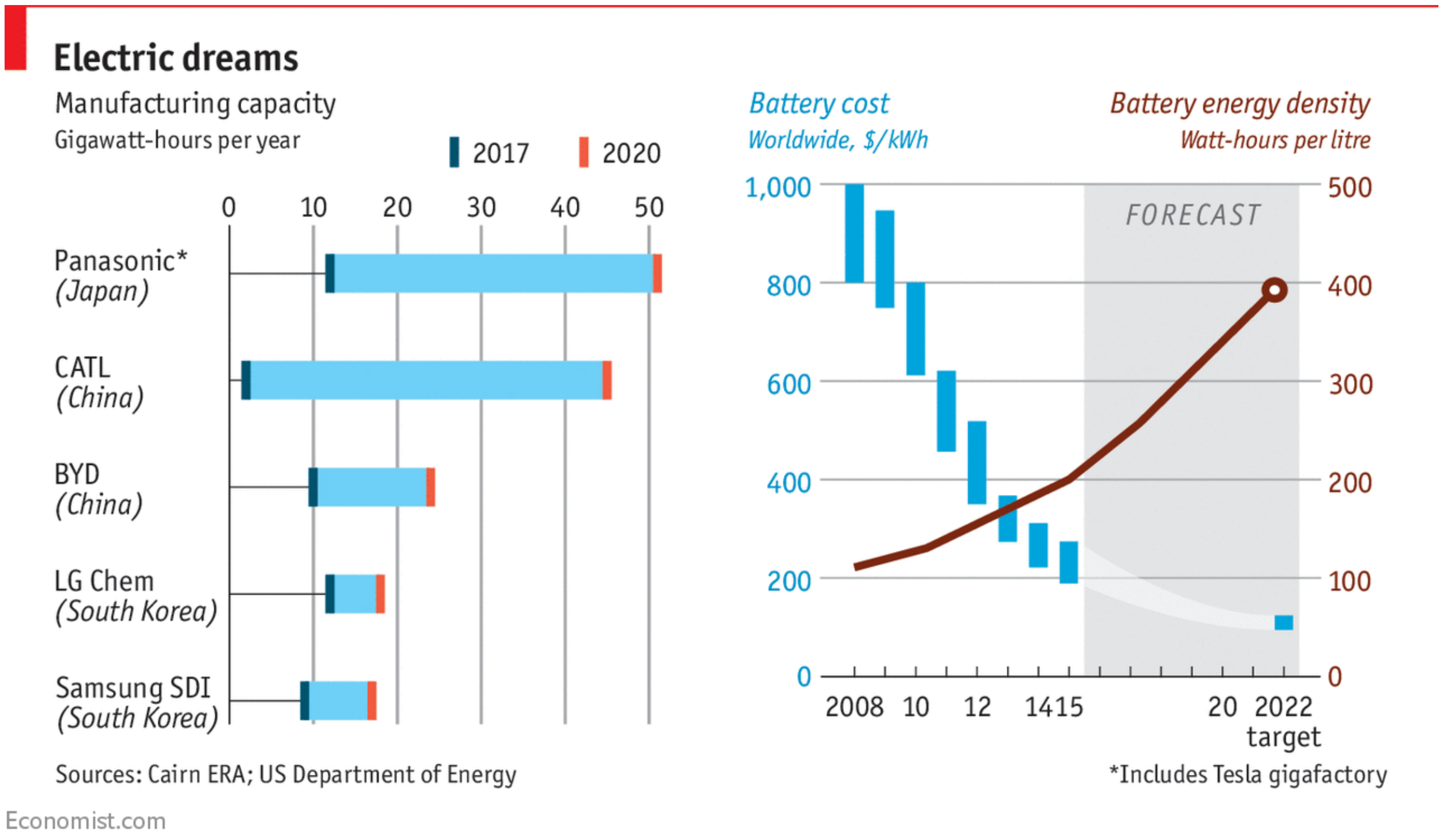
Technology: Lithium Ion

- Great leap forward (c 1980)
- First commercial battery c 1991, Sony
- More expensive, cost reducing quickly
- A family of cell chemistries
  - Lithium Iron Phosphate ($LiFePO_4$ aka LFP)
  - Lithium Polymer
  - Lithium Nickel Magnesium Cobalt Oxide (aka NMC)
  - Lithium Titanate (aka LTO)
- High energy density
- Some Lithium cell chemistries are less stable, and flammable
- Mobile electronics, EVs
- More flexible charging profile, low ‘memory’
- Many vendors, very large global investment
- Cycles: thousands – tens of thousand
- Production economies of scale: enormous

AA cell vs 18650 Lithium cell
~12Wh energy, ~49g

NEWENERGY Thinking

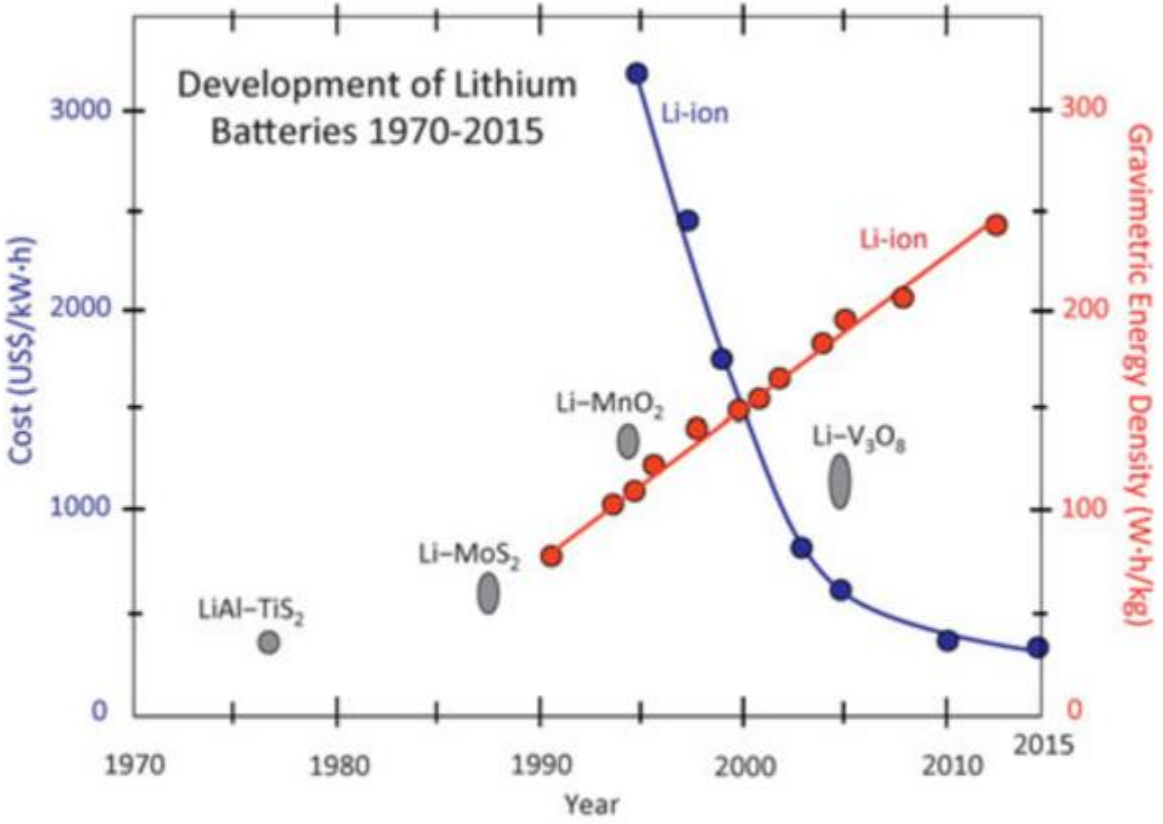
Lithium Ion trends #1



https://www.economist.com/graphic-detail/2017/08/14/the-growth-of-lithium-ion-battery-power

Lithium Ion trends #2

- 1991: 3000 USD/kWh
- 2015: 400 USD/kWh
- 2019: 100 USD/kWh (est)



https://arena.gov.au/blog/arenas-role-commercialising-big-batteries/

NEWENERGY Thinking

Technology: Flow batteries

- Liquid electrolyte (pumped)
- Zinc-bromine solution
- Increase capacity by increasing reservoir size
- Full rated capacity available
- Redflow – Australian tech
- Compact
- 10-year / 36.5MWh warranty

What’s in a typical battery module

- Cells
- Charger
- Battery Management System (BMS)
- Battery inverter

Economics of energy storage

- Arbitrage:
  - charge from cheap energy,
  - discharge to avoid expensive energy
- Up-front cost
  - Does it include battery inverter?
  - $/kWh (kWh of capacity)
  - Amortised storage cost per kWh delivered over warranted life
    - ~+$0.25 - ~+$0.90 (plus inverter)
- Energy cost: storage cost + charging cost

Battery is net energy user

- Round-trip efficiency – say 85%
- 15% charging losses
- For say 4000kWh charging energy in a year
- 3400kWh delivered energy
- 600kWh lost energy charging battery
    - Comparable to an efficient hot water system

Battery utilisation

- Utilisation – proportion of available capacity that actually gets used
- Perfectly utilised battery:
  - Complete charge, followed by
  - Complete discharge
- Storage capacity might not get used because (on any given day):
  - Not enough sun to charge it, and/or
  - Not enough load to use it

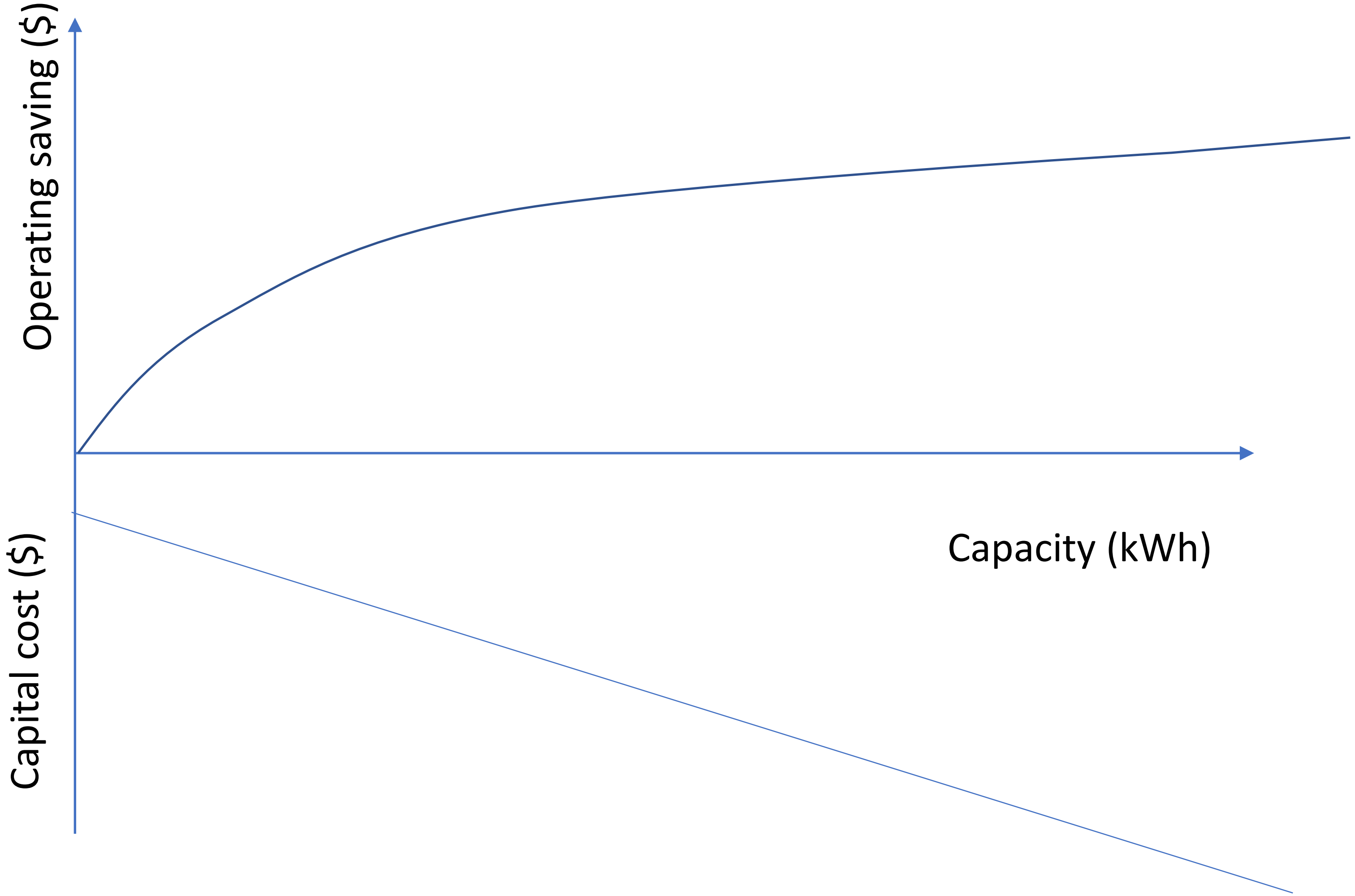
NEWENERGY Thinking

Battery utilisation trade off

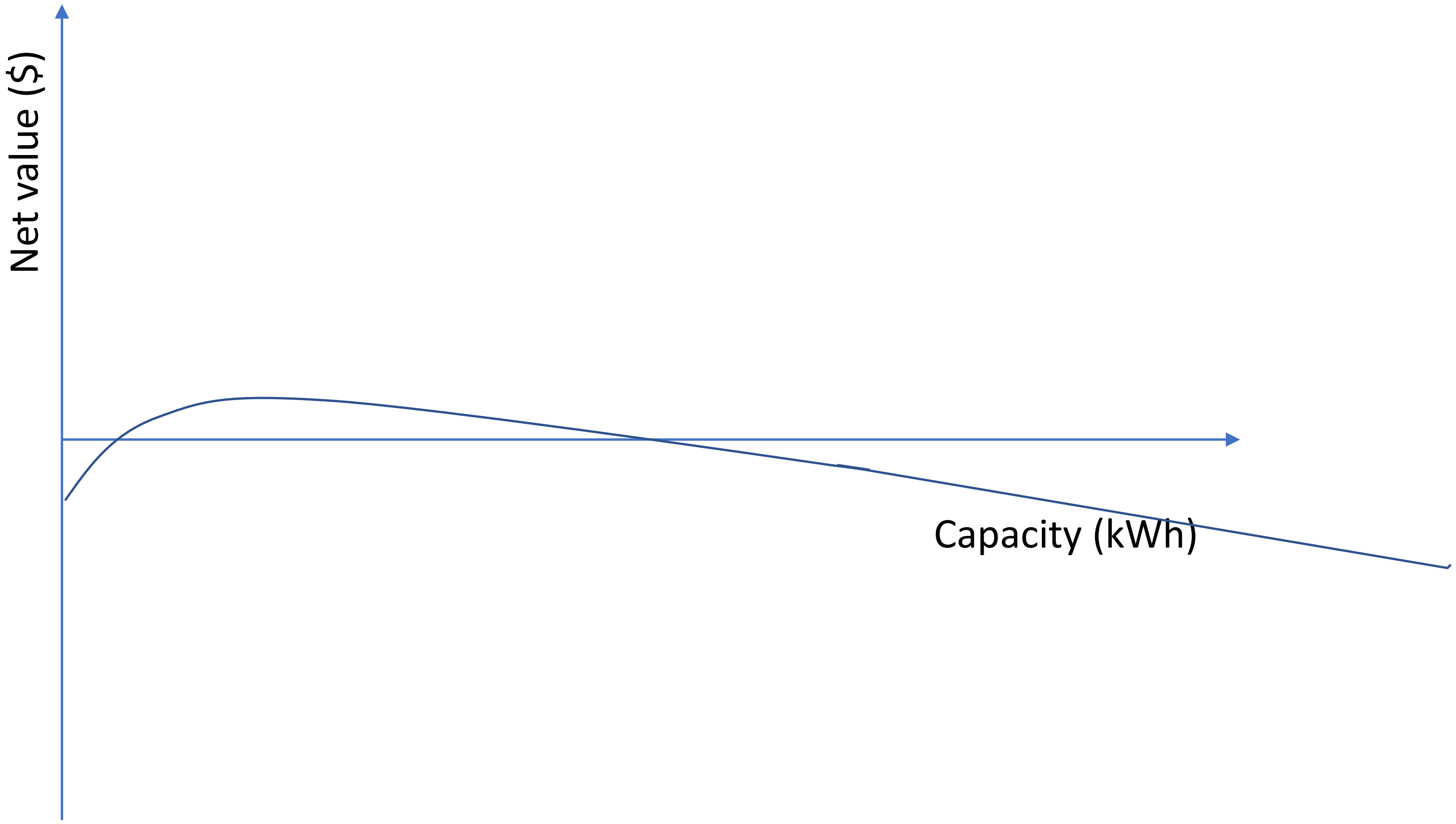
- Trade off
  - Unused capacity is wasted capital
  - Unavailable capacity means exporting
  - Uncharged capacity means buying from the grid
- Same with hot-water system size
- Small systems (cheaper) will be well utilised but may leave you without enough stored energy

NEWENERGY Thinking

Capacity optimisation – how much is best?



Capacity optimisation
- the goldilocks problem



Battery capacity required?

- What are your goals?
  - Highest net savings?
  - Lowest total grid demand?
  - Least chance of running out of power?
- It’s complicated: Depends on grid configuration/reliability, battery cost, demand characteristics, solar resource, grid tariffs, weather, backup generator.

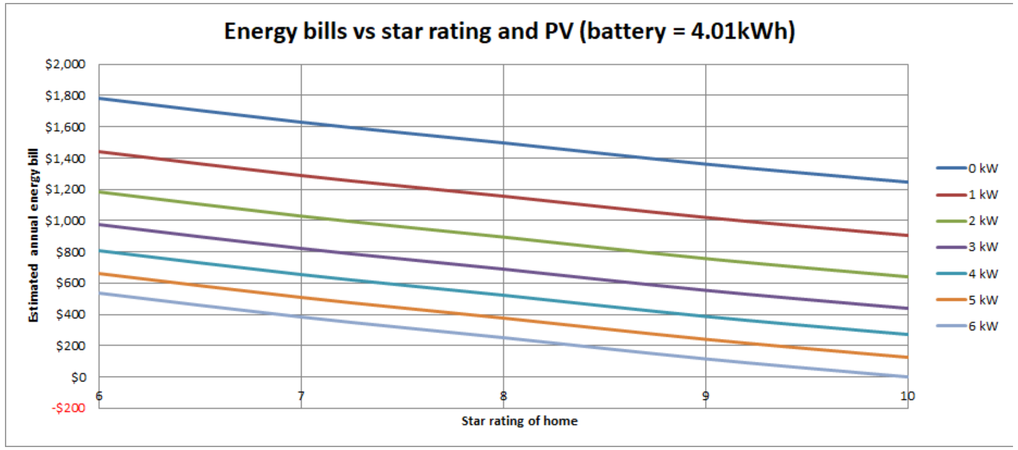
Solar resource

- PV daily output annual avg (Melbourne): 3.5kWh / kWp
- Daily average for worst month: 1.8kWh / kWp (1:1.8)
- Daily average for best month: 4.8kWh / kWhp (1.4:1)
- Winter is more of an outlier than summer
- Cloudy days ~ 0.6 kWh / kWp (1:6 annual daily avg)
- Implication for batteries:
  - In winter when you need it most it's hard to have enough PV capacity to charge your battery.

NEWENERGY Thinking

Modelling the benefits

- 1. My spreadsheet model for all-electric homes
  - https://newenergythinking.com/blog/



PV capacity [kW]	8	**KEY INPUTS**
NatHERS star rating	8	
Battery usable capacity [kWh]	4.0	
Occupancy (time proportion)	100%	OTHER INPUTS
Occupancy (people)	4	
Energy usage practice	RELAXED	
Floor area [m2]	134	
Net annual energy bill	**$0**	**KEY OUTPUT**
Net energy positive?	YES	OUTPUTS
Savings from PV and battery [per annum]	$1,485	
Solar generation [kWh/annum]	10512	
Grid export [kWh/annum]	7762	
Grid import [kWh/annum]	1829	
Gross consumption [kWh/annum]	4428	
Net supply (I-E) [kWh/annum]	-5932	
Battery avoided import	1164	
Battery losses [kWh/annum]	151	
Well-utilised battery?	NO	
Export rate	73.8%	
Battery utilisation	79.5%	

- 2. ATA's Sunulator model

Batteries and blackouts

- Batteries don’t necessarily give blackout protection
- Anti-islanding – inverters shut down on grid failure
- Full blackout protection needs:
  - grid isolation relay
  - high-powered battery inverter
- Partial blackout protection needs backup circuit powered from battery inverter (like a UPS)
- Some battery systems include backup. Don’t assume
- *eg* Powerwall’s **Backup Gateway.**

NEWENERGY Thinking

Batteries and the smart grid

- Home perspective: optimal battery operation needs:
  - Smart algorithms
  - Knowledge of consumption patterns
  - Weather/solar data and forecast
  - Ability to sell energy to exploit peak-price events
  - Ability to charge from off-peak when appropriate
  - Ability to divert surplus energy (*eg* hot-water, pool pump)

- Grid perspective: home batteries useful when:
  - Reducing general demand variability (easy)
  - On-demand source of generation to mitigate peak-price events (hard)
  - On-demand source of stabilisation (hard)
  - Virtual power plants

Smart grid enabler: Reposit Power

- Makes home batteries part of a distributed virtual power plant
- Allows on-demand selling of power to the grid
  - Peak demand events
  - Good return to home owners
- Smart control of charging
- Battery-agnostic
- Australian-made and -owned company

NEWENERGY Thinking

Reposit Storage Savings Case Study:
SMA Sunny Boy Storage with Powershop Grid Impact

Reposit Feature	Individual Savings	Accumulated Savings
Reposit replacing the standard battery monitoring	$600	$600
Reposit GridCredit joining bonus	$100	$700
Reposit GridCredits year 1	$156	$856
Reposit smart off peak charging year 1 (Vic average)	$64	$920
Reposit GridCredits year 2	$156	$1176
Reposit smart off peak charging year 2 (Vic average)	$64	$1240
Reposit standard installation cost of $1200 can be pay for itself in only 2 years.		
Reposit improves the payback of the battery and adds more savings over time.		

Available Lithium batteries on the market

- LG Chem Resu 10
- SimpliPhi PHI3.4 Smart-Tech
- SunGrow SBP4K8
- Leclanche Apollion Cube
- Soltaro
- GCL E-KwBe 5.6
- Arvio Sirius Capacitor Module
- Delta Hybrid E5
- Sonnenschein @ Home Lithium
- ELMOFO E-Cells ALB52-106
- Akasol neeoQube
- BYD B-Box LV
- Fronius Solar Battery

- PowerPlus Energy LiFE series 48V
- DCS PV 5.0DCS PV 5.0DCS PV 10.0
- SolaX 3.3 SolaX 3.3 SolaX 6.5
- BMZ ESS3.0
- Pylontech US2000B
- Tesla Powerwall 2
- Trinabess Powercube
- SolarWatt MyReserve Matrix
- Hansol AIO 10.8Hansol AIO 10.8Hansol AIO 7.2
- VARTA Pulse 3VARTA Pulse 3VARTA Pulse 6
- Enphase AC Battery

- Magellan HESS
- Sonnenbatterie
- Opal Storage
- Senec.home Li 10
- ZEN Freedom Powerbank FPB16
- SolaX Power Station
- Sunverge SIS
- Alpha-ESS ECO S5

(from solarquotes.com.au)

NEWENERGY Thinking

Other batteries

- Aquious Hybrid Ion
  - Aquion Aspen 48S-2.2
  - Fusion Power Systems Titan-3
- Flow battery
  - Redflow Zcell
- Sodium Nickel Chloride
  - GridEdge Quantum
- Lead
  - Hybrid Home Plus

NEWENERGY Thinking

Concluding remarks

- $10,000+ is a lot for a system that stores $3 of electricity at a time
- Battery cost reduction is mostly being driven by EVs
- Needs to be structural incentives for home batteries

Recommendations

- Who: anyone
  - Explore the possible scenarios with modelling
- Who: economically motivated suburban Melbournian
  - Wait for economics to improve further
  - In the mean time, reduce demand and get (more) solar
- Who: environmentally motivated
  - Get hybrid solar PV with large PV and medium-size battery (5-10kWh)
  - Use Lithium Ion technology
  - Get blackout protection
  - Get Reposit for smart-grid integration

Keep in touch

- I hang out at the group ‘My Efficient Electric Home’ on Facebook
  https://www.facebook.com/groups/996387660405677

- Email: richard@newenergythinking.com

NEWENERGY Thinking