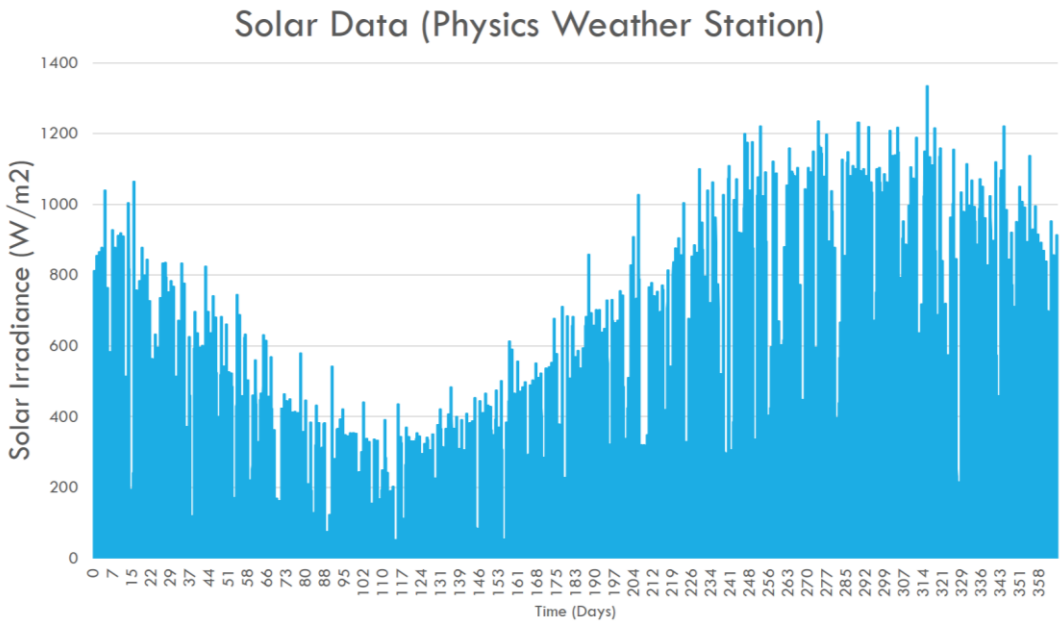
MATCHING SOLAR PHOTOVOLTAIC ELECTRICITY GENERATION TO DEMAND PROFILES

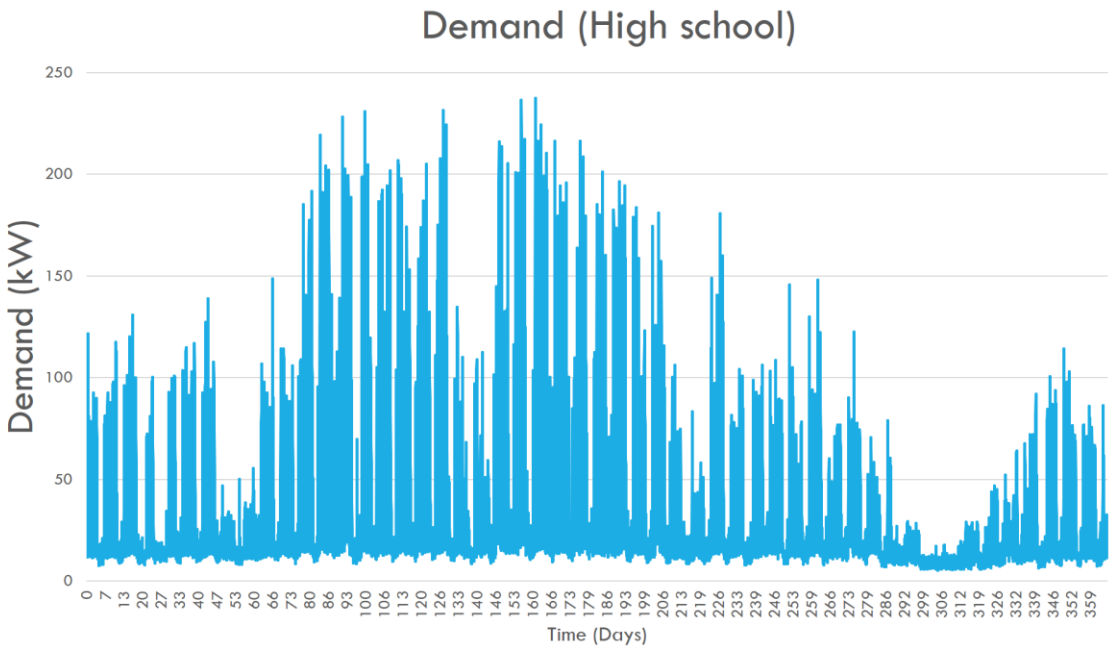
Tupuivao Vaiaso
Dr. Michael Jack

KEY ISSUE WITH RENEWABLE ENERGY IS VARIABILITY

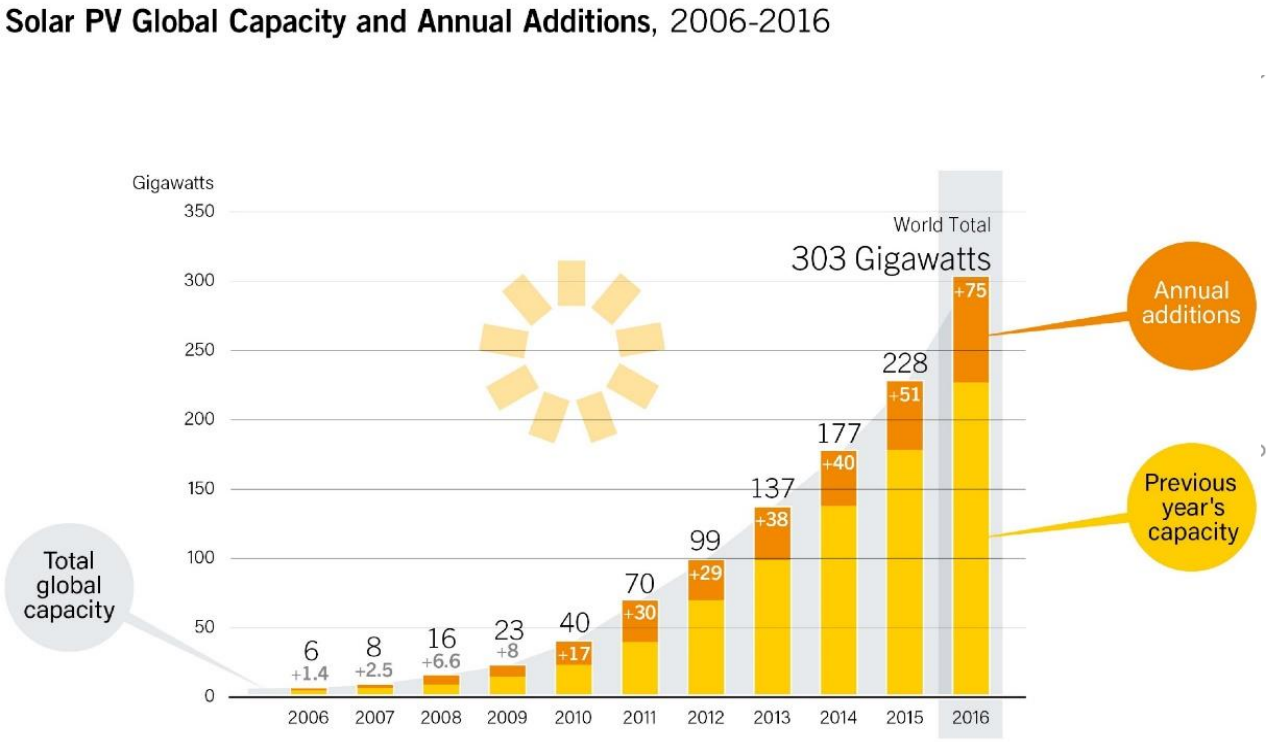
Renewable Energy sources are not dispatchable and never match with demand.

Demand is variable(e.g. commercial, residential etc.)

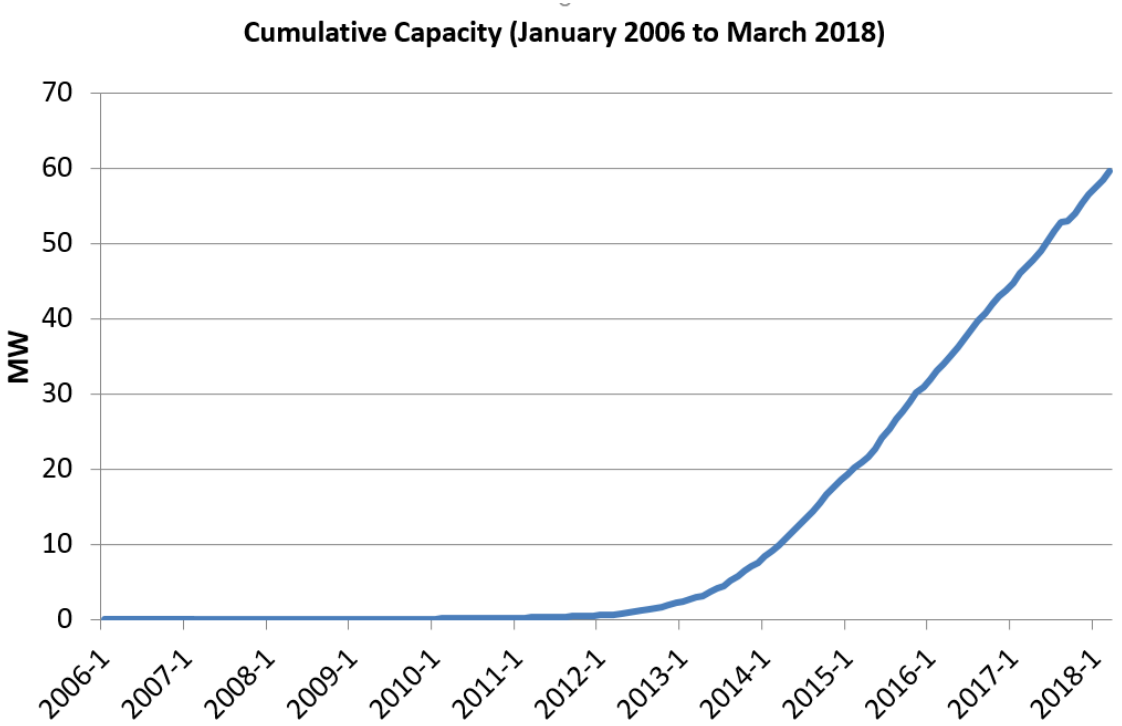




Solar Photo Voltaic (PV) Uptake Trends



303 GW global capacity of PV installation (2006-2016) [1]



60MW PV installation in NZ (2006-2018)[2]

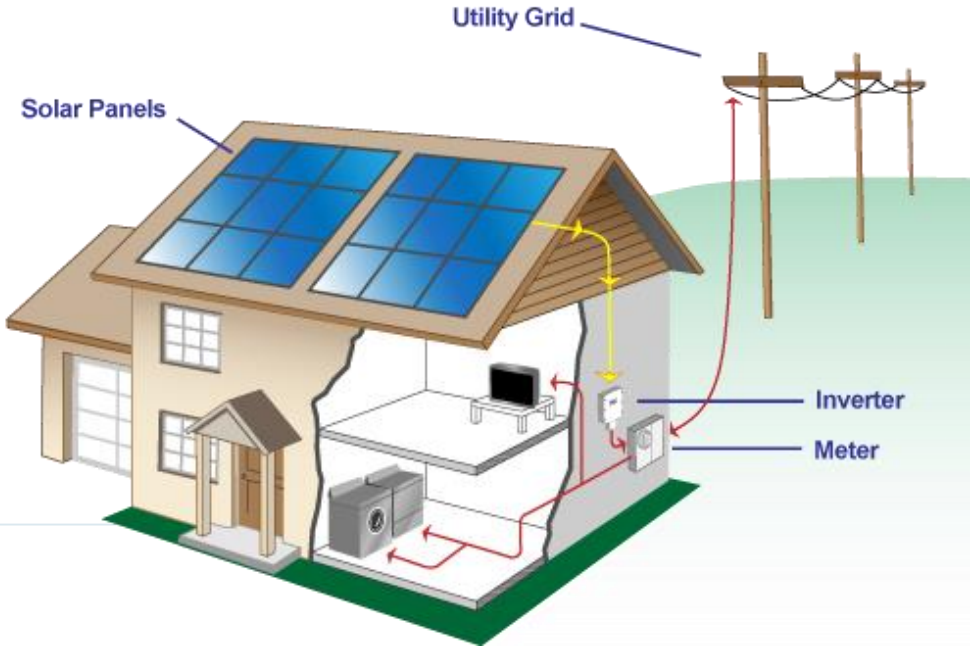
1: "REN21 Renewables 2017 Global Status Report".

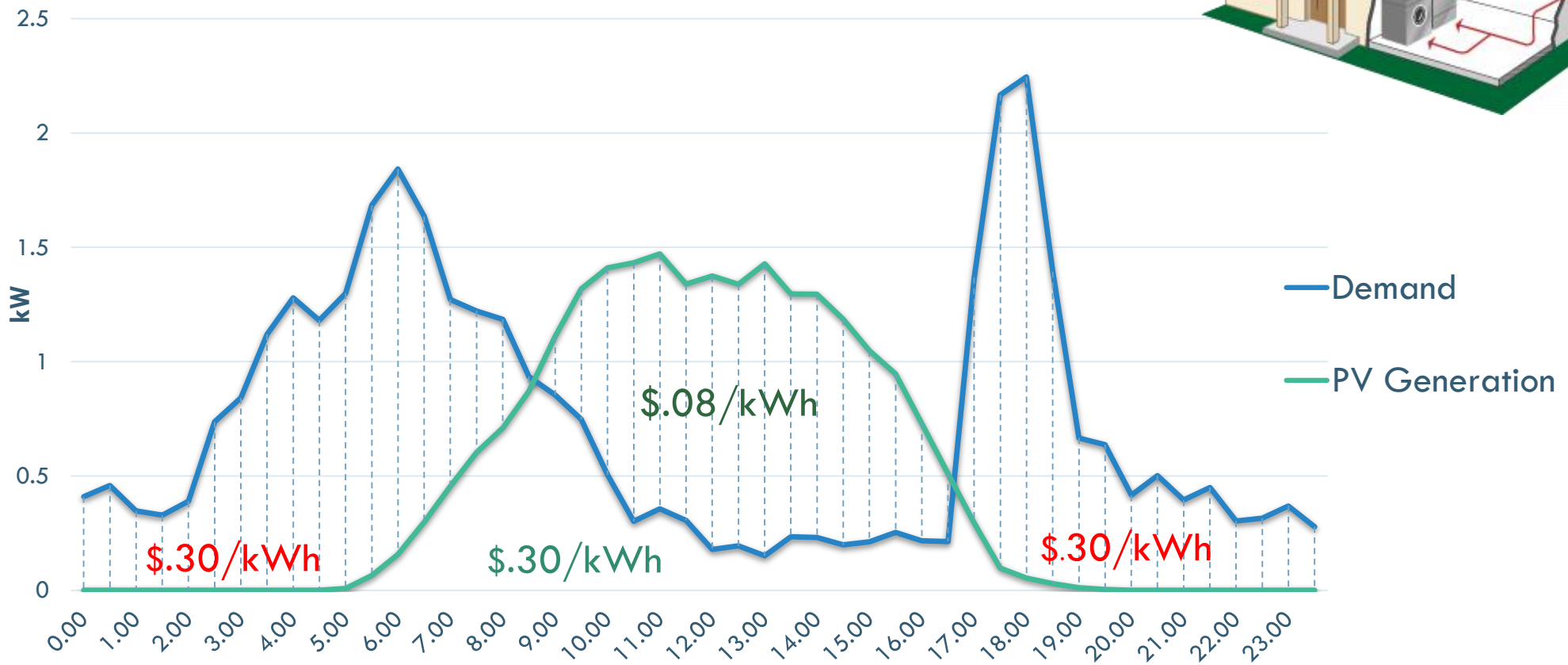
2: "Electricity Authority" https://www.emi.ea.govt.nz Accessed: 2018-04-10.

Retail Price of Electricity in New Zealand

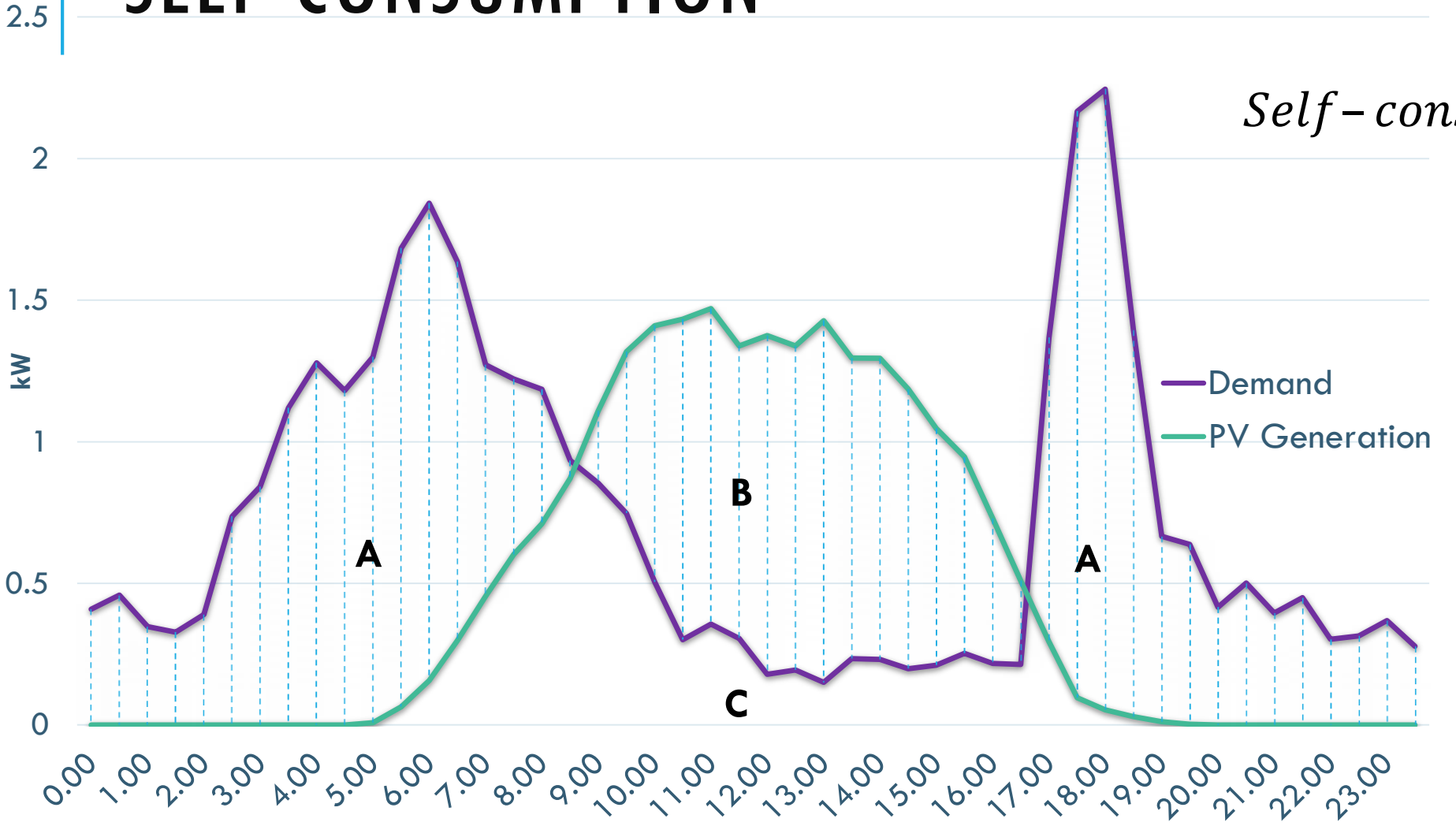
Import Price = $.30/kWh

Export Price =$.08/kWh





SELF-CONSUMPTION



$$Self-consumption = \frac{C}{B + C}$$

ECONOMICS

Net Present Value (NPV)

$$NPV = \sum_{n=1}^{Y} \frac{B - O}{(1+r)^n} - C$$

B - Benefit/Revenue

$$B = [SI + (1 - S)E]P_A$$

I: \$.30/kWh E: \$.08/kWh

Y- 20 to 25 years

r- interest rate (6%)

S - Self-Consumption (percentage)

P_A -PV System Generation (kWh)

O - Operation and Maintenance

C - Upfront Capital cost (Residential: \$3000/kW, School: \$2000/kW)

$NPV > 0$ Good Investment

$NPV < 0$ Bad Investment

OPTIMISING SELF-CONSUMPTION

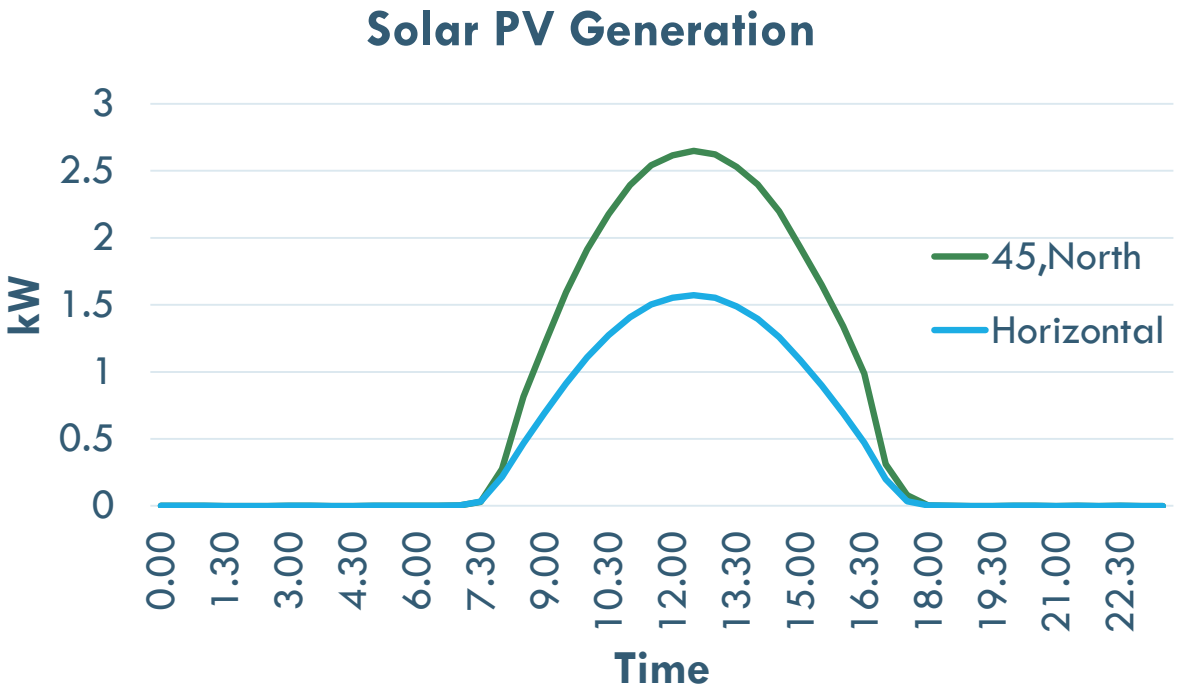
Storage

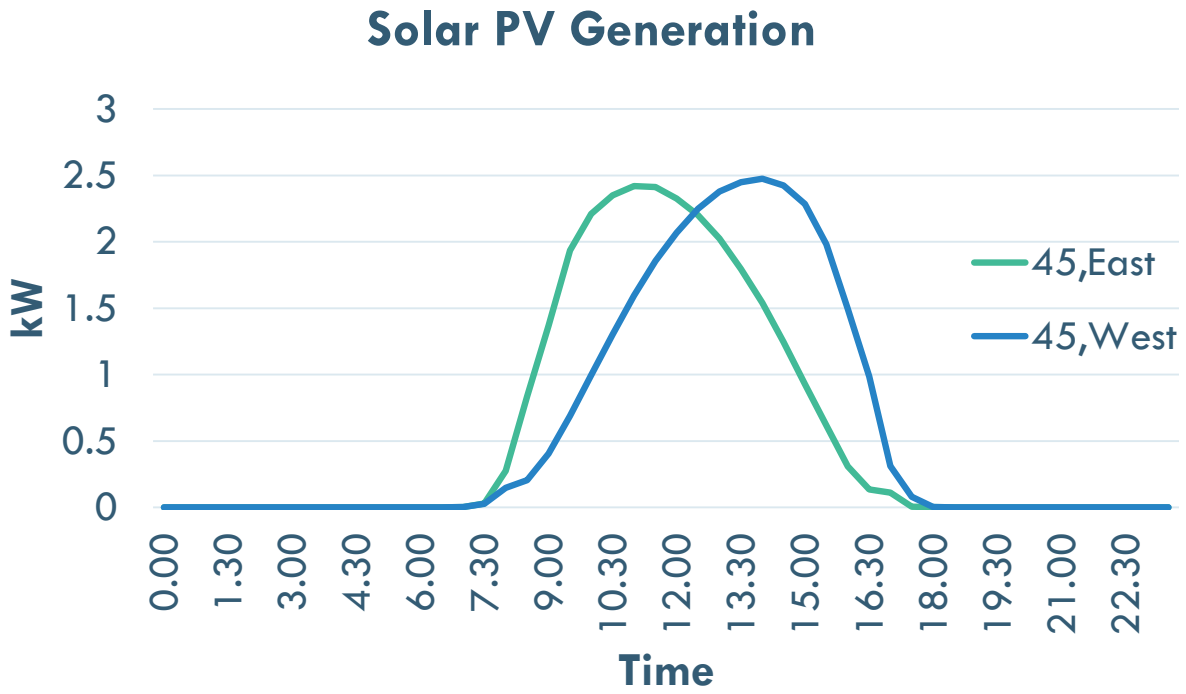
Demand Side Management (DSM)

Matching Demand Profiles to PV Generation

Optimise Tilt and Orientation

Main Focus of this project





METHODOLOGY

Solar Data *(Physics Weather Data)*

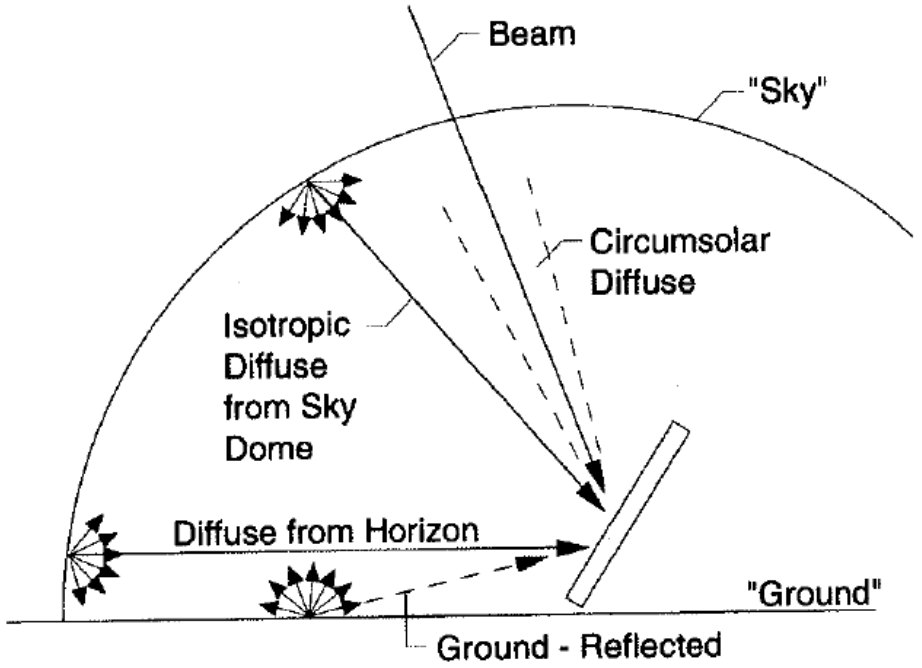
Isotropic Diffuse model

Demand Profile (High school & Residential)

Implement in MATLAB

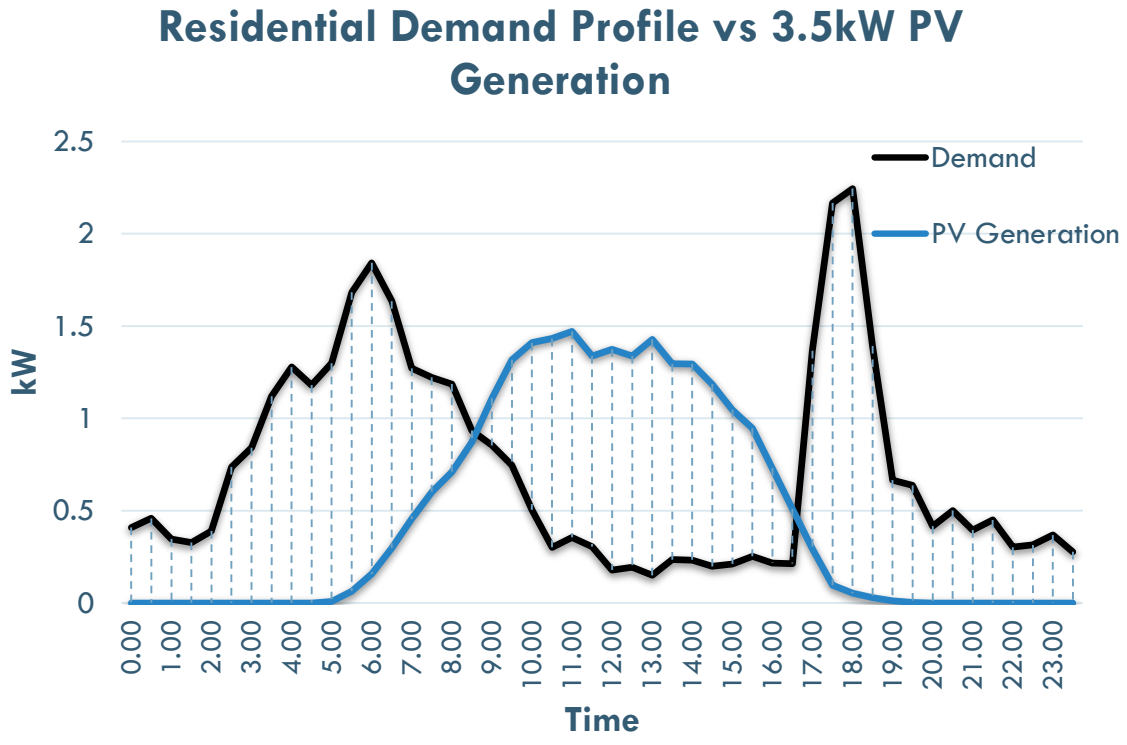
Calculate Self-consumption and NPV

Optimising PV Panels Orientation

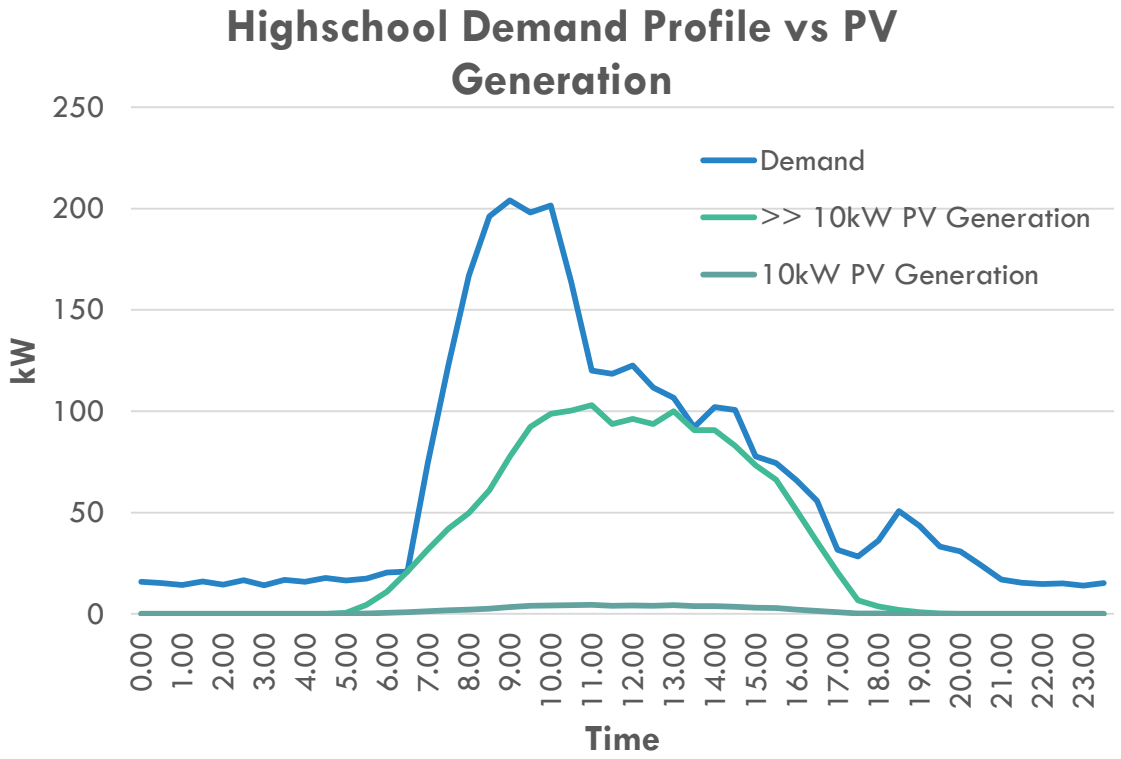


Source: J. Twidell and T. Weir, Renewable energy resources. Routledge, 2015.

RESULTS:



Self-consumption = 32%

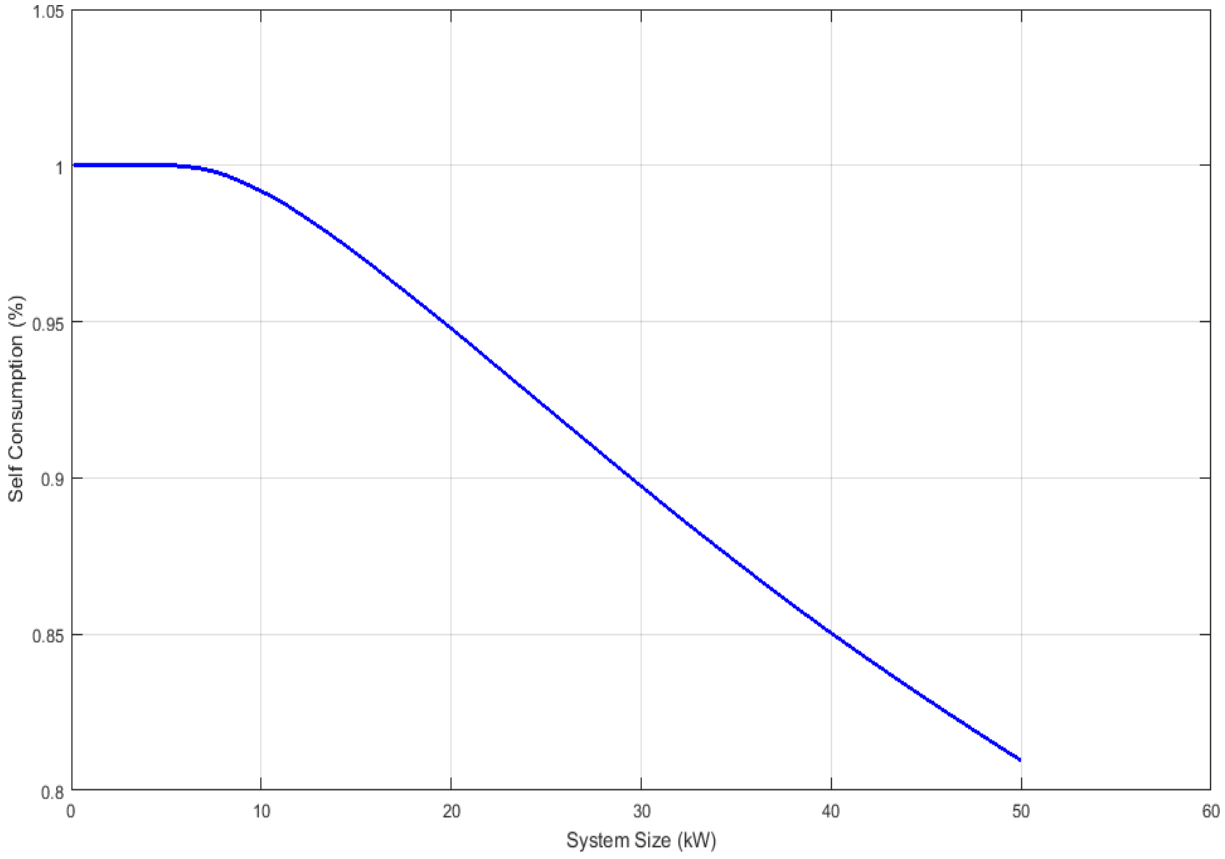


Self-consumption = 100%

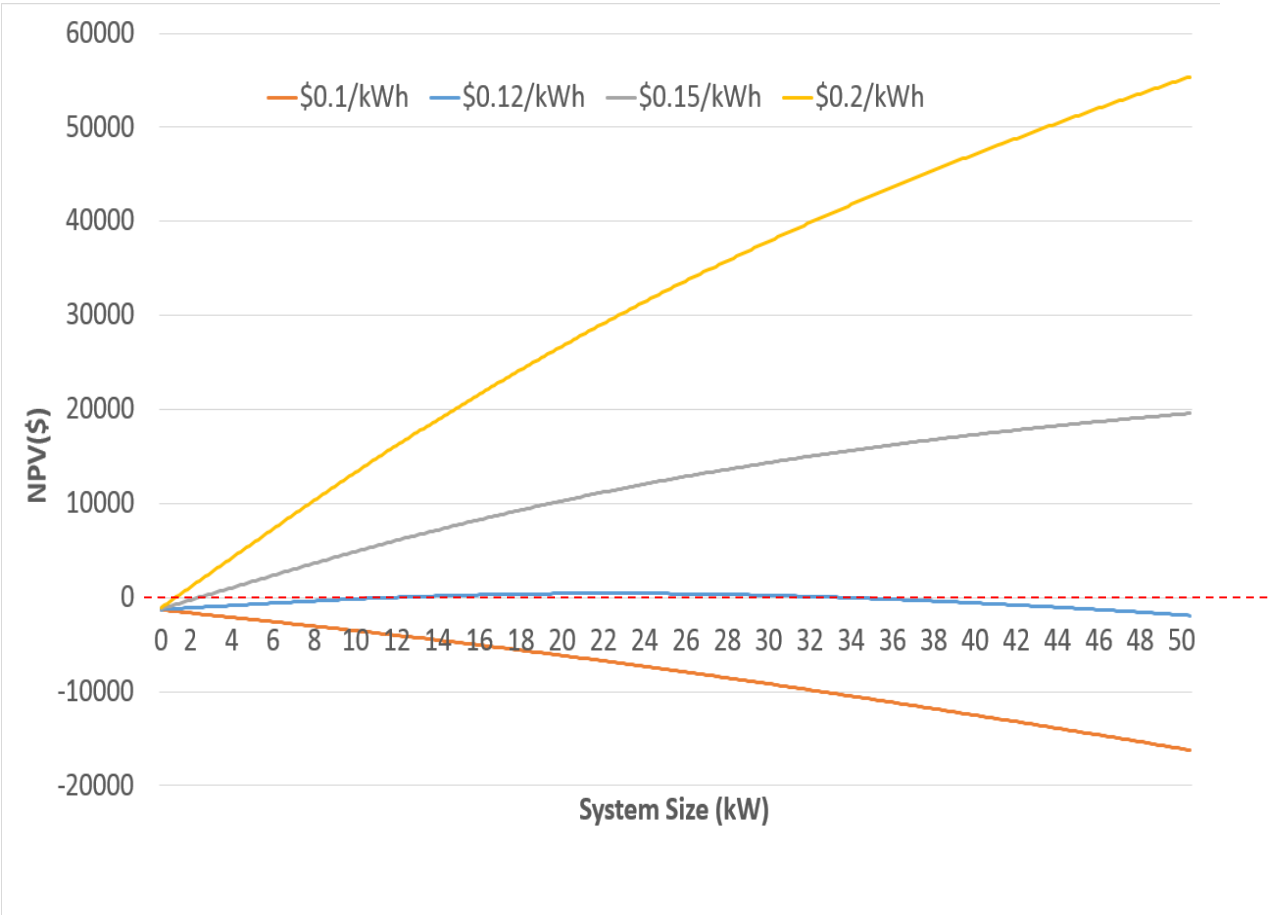
RESULTS:

High school

1) Self Consumption (%) vs System size (kW)



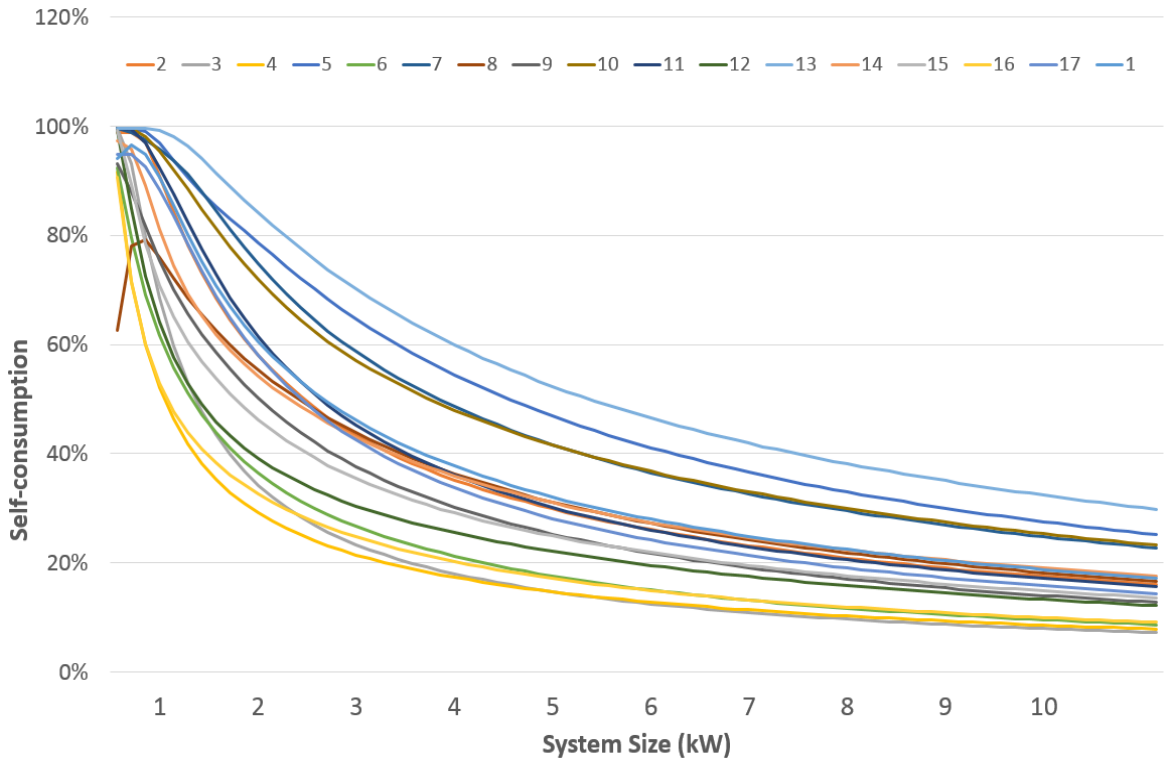
2) NPV ($) vs System size (kW)



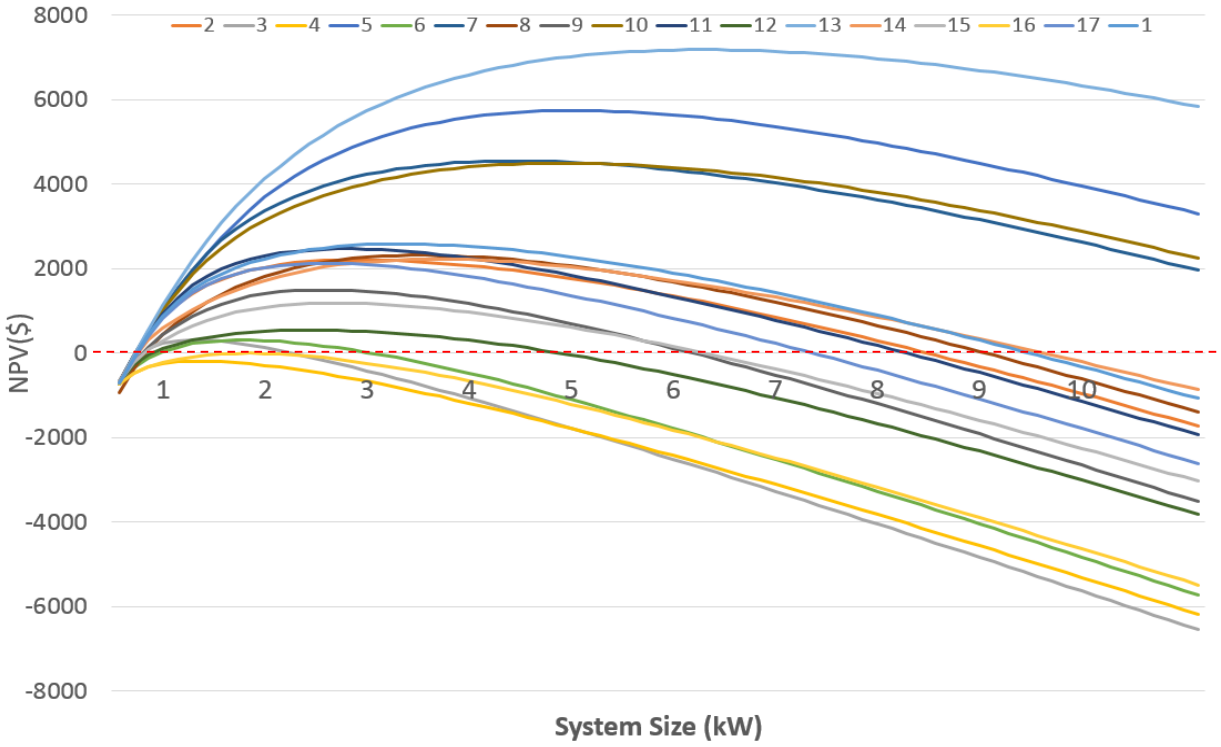
RESULTS:

Residential Profiles

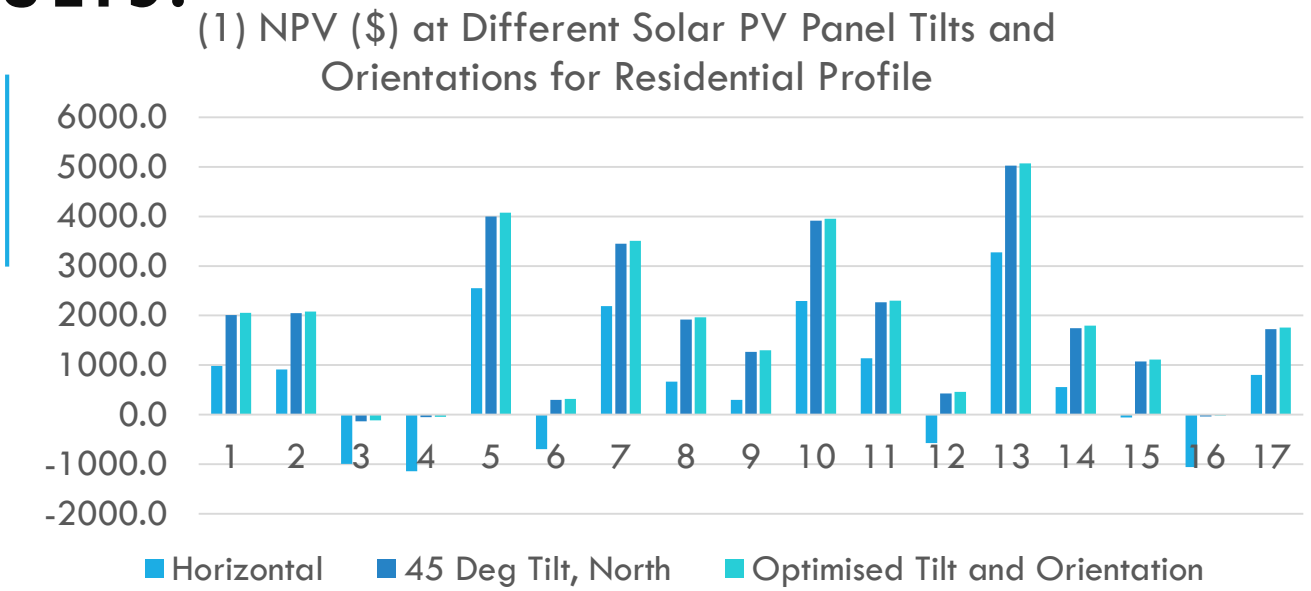
1) Self Consumption (%) vs System size (kW)

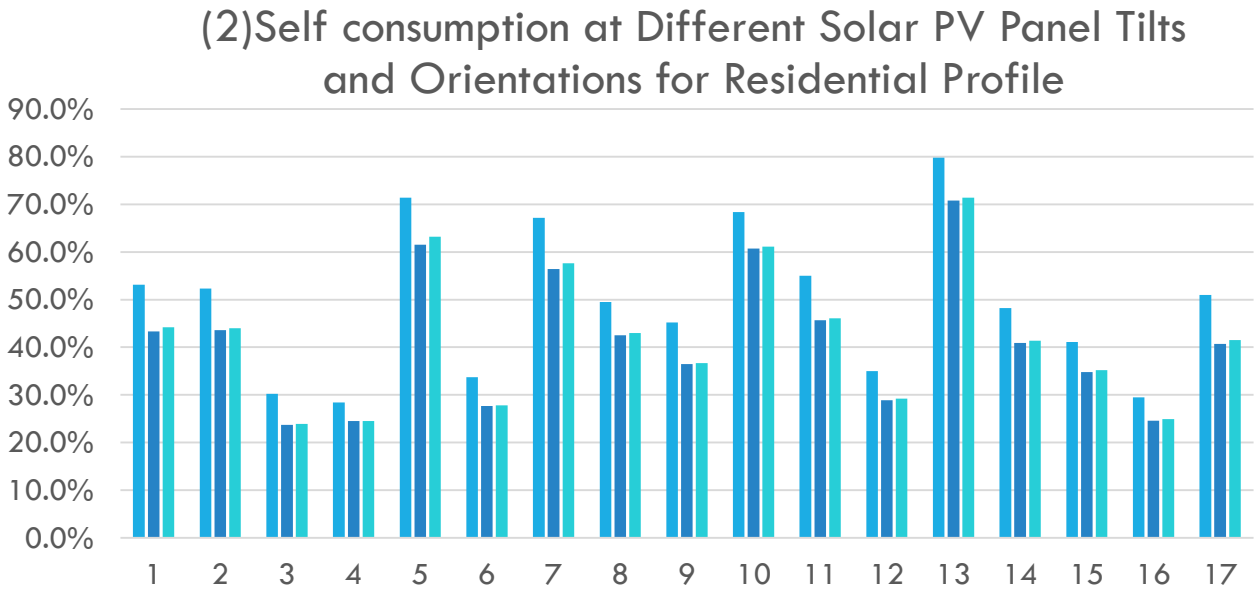


2) NPV ($) vs System size (kW)



RESULTS:





House	45◦ **Tilt, North**		Optimised Tilt and Orientation	
	Change in Self-Consumption	Change in NPV	Change in Self-Consumption	Change in NPV
1	-9.9%	104.7%	1.0%	2.3%
2	-8.7%	124.6%	0.4%	1.6%
3	-6.5%	86.6%	0.1%	12.9%
4	-4.0%	95.4%	0.0%	19.5%
5	-10.0%	56.5%	1.8%	1.9%
6	-6.0%	142.8%	0.1%	5.9%
7	-10.8%	57.4%	1.2%	1.7%
8	-7.0%	189.1%	0.5%	2.4%
9	-8.7%	324.9%	0.2%	2.4%
10	-7.7%	70.8%	0.4%	0.9%
11	-9.3%	99.6%	0.4%	1.5%
12	-6.2%	174.6%	0.3%	6.8%
13	-9.0%	53.3%	0.6%	0.9%
14	-7.3%	213.6%	0.5%	2.7%
15	-6.3%	203.6%	0.4%	3.3%
16	-4.8%	96.7%	0.2%	55.6%
17	-10.4%	115.5%	0.9%	2.2%

SUMMARY

- School Profile is a better match for Solar PV System (self- consumption of > 80% for a range of system sizes (5 to around 50kW)).
- Import price must be greater than $0.10/kWh.
- Residential Profiles self-consumption ranges form <20% - 80%
- System size for most houses have found to be in the 2kW to 5kW range for good NPV.
- Altering PV panel orientation to increase self-consumption has a minimal impact of improving the economics of solar PV.
- Other methods of increasing self consumption such as shifting load to the middle of the day should be explored.

Current Work:

100% renewable electricity generation for Samoa

THANK YOU