Future Grid Research Cluster

Symposium - Project update (P1 - storage)

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Our approach

Work sequence

- Stage 1 Costs & benefits of storage at household level
- Storage only, PV+storage, EV+PV (and other DG) + stationary storage
- Stage 2 Costs & benefits of storage at feeder (and then) distribution level
- Stage 3 Costs & benefits of storage at transmission & whole of system level
- Stage 4 Effect of storage on NEM wide planning & operation

Our approach

- Storage to start at low voltage distribution level (household) but in longer time-frame - say to 2035 - extend to higher voltages as cost reduces (EVs to provide additional storage if peaks still costly).
  - Storage at household level may already be economic, and combination of PV + storage is compelling [but customer becomes prosumer with significant implications for networks]
- Modelling approach is to work with groups of 50 homes on a single feeder and:
  - Understand effect of load, PV, tariffs etc on uptake of storage (half-hr or better) - model power, voltages on feeder
  - Aggregate groups, which may be e.g. inner city, suburban, fringe, industrial, up to 3000 homes
  - Aggregate upwards to HV connection point providing net (city) load to Power Systems group

Our approach

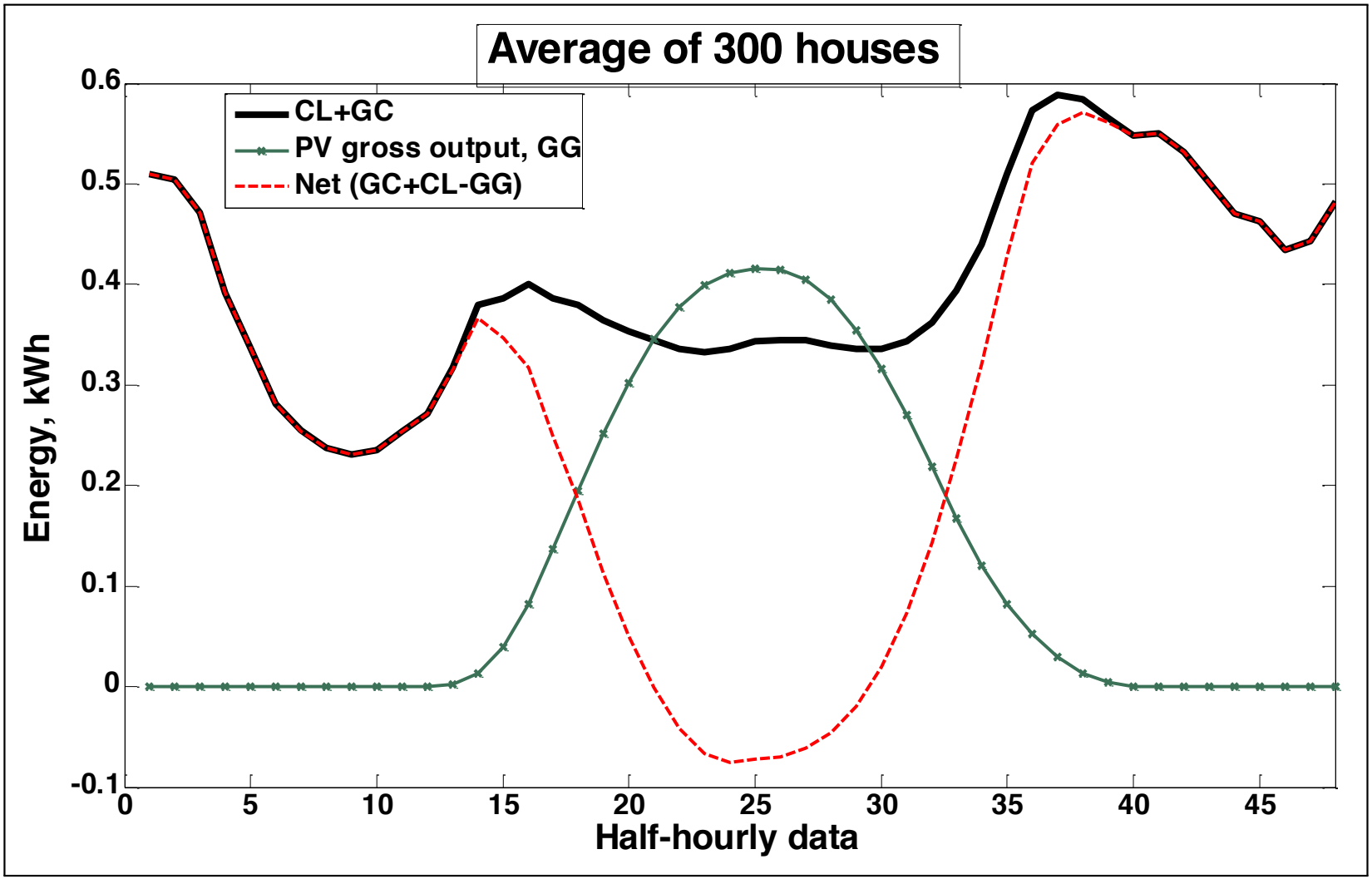
The main challenge:

- In a larger perspective, the customers will choose various technologies and sizes, not necessarily the optimal ones.
- The uptake of PV-battery system is function of a few key parameters i.e. FiT, capital costs, tariffs and regulations.
- Therefore grid level modelling requires consideration of numerous uncertain and stochastic issues...

Questions to answer

- What "systems" will households (and some commercial, light industrial) find financially feasible/attractive?
- What combination of cost/size/performance will emerge?
- Where, when and how will it be deployed?
- *How will extensive deployment affect grid operation and planning*

Average Ausgrid data - daily average



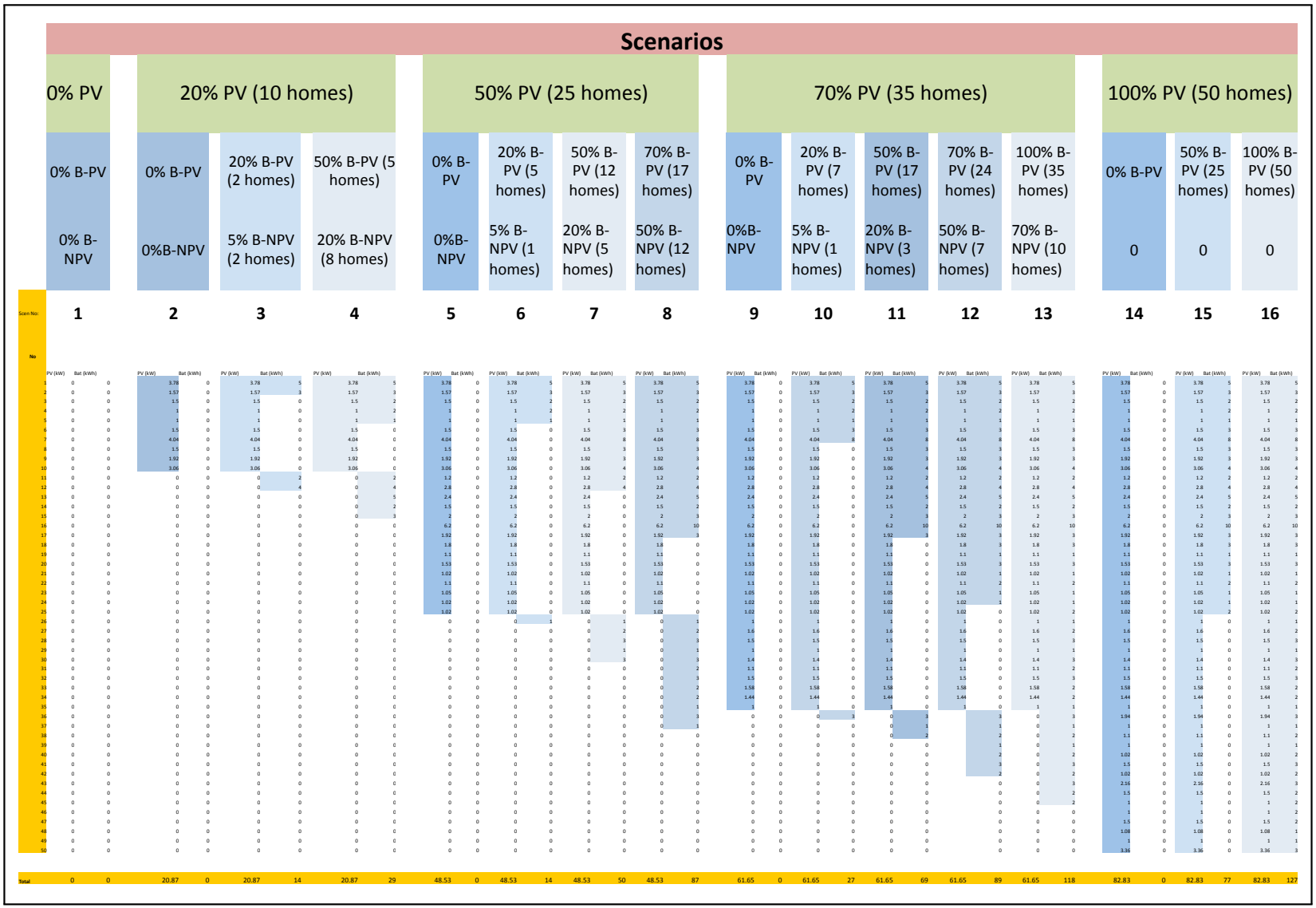
GC = General Consumption (primary tariff, either inclining block or time of use rates)
CL = Controlled Load Consumption (off peak 1 or 2 hot water)
GG = Gross Generation

PV-battery uptake scenarios

Scenario	PV uptake (%)	Battery uptake (% homes w PV)	Battery uptake (% homes w/o PV)
1	0	0	0
2	20	0	0
3	20	20	5
4	20	50	20
5	50	0	0
6	50	20	5
7	50	50	20
8	50	70	50
9	70	0	0
10	70	20	5
11	70	50	20
12	70	70	50
13	70	100	70
14	100	0	0
15	100	50	0
16	100	100	0

NB: these are not the high level "scenarios" discussed in other projects

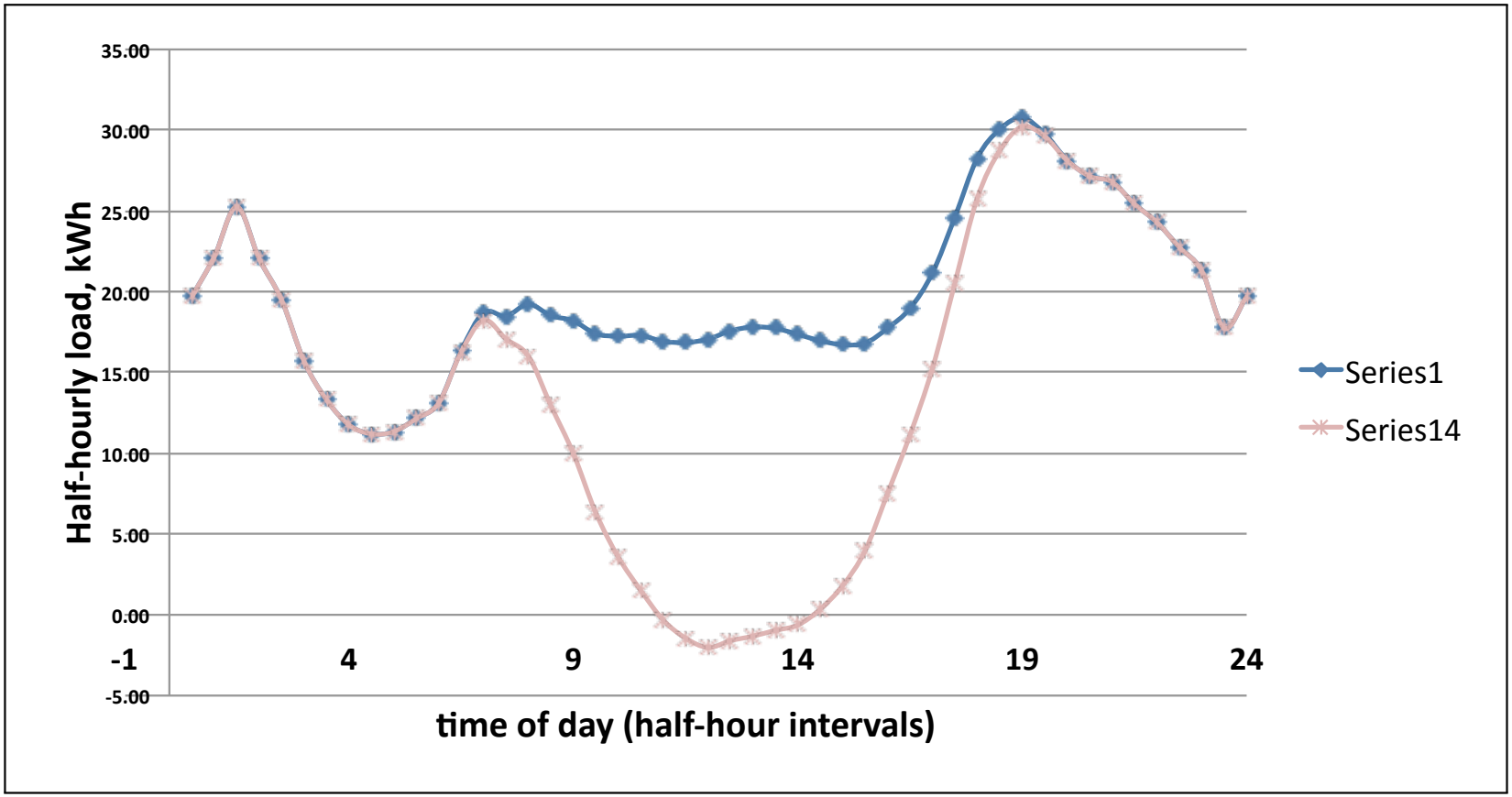
Structure of scenarios



Structure of scenarios - sample (x2 PV)

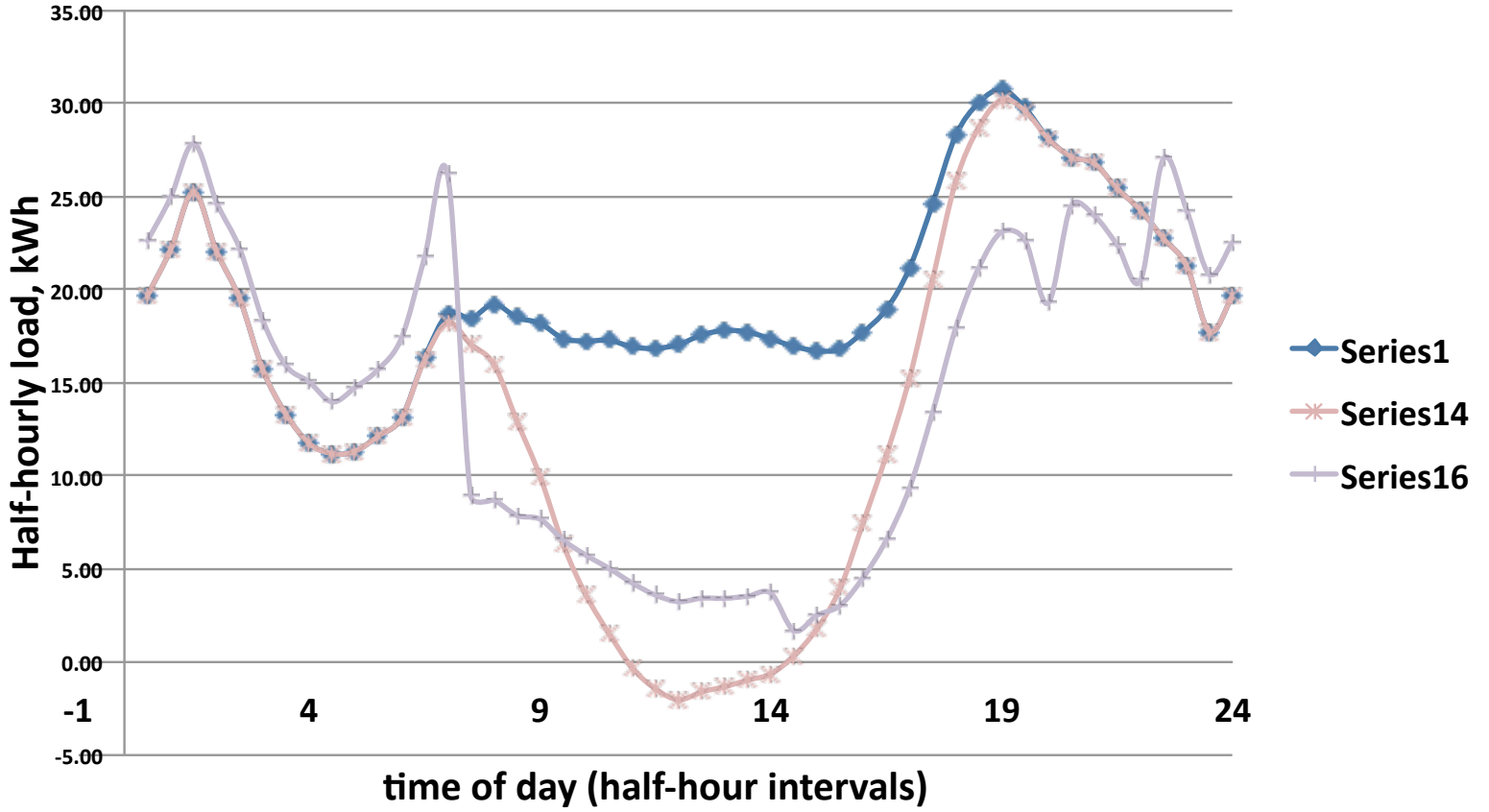
	100% PV (50 homes)			
100% B-PV (35 homes)	0% B-PV	50% B-PV (25 homes)	100% B-PV (50 homes)	
70% B-NPV (10 homes)	0	0	0	
13	**14**	**15**	**16**	
PV (kW)	Bat (kWh)	PV (kW)	Bat (kWh)	PV (kW)	Bat (kWh)	PV (kW)	Bat (kWh)
7.56	5	7.56	0	7.56	5	7.56	5
3.14	3	3.14	0	3.14	3	3.14	3
3	2	3	0	3	2	3	2
2	2	2	0	2	2	2	2
2	1	2	0	2	1	2	1
3	3	3	0	3	3	3	3
8.08	8	8.08	0	8.08	8	8.08	8
3	3	3	0	3	3	3	3
3.84	3	3.84	0	3.84	3	3.84	3
6.12	4	6.12	0	6.12	4	6.12	4
2.4	2	2.4	0	2.4	2	2.4	2
5.6	4	5.6	0	5.6	4	5.6	4
4.8	5	4.8	0	4.8	5	4.8	5
3	2	3	0	3	2	3	2
4	3	4	0	4	3	4	3
12.4	10	12.4	0	12.4	10	12.4	10
3.84	3	3.84	0	3.84	3	3.84	3
3.6	3	3.6	0	3.6	3	3.6	3
2.2	1	2.2	0	2.2	1	2.2	1
3.06	3	3.06	0	3.06	3	3.06	3
2.04	1	2.04	0	2.04	1	2.04	1
2.2	2	2.2	0	2.2	2	2.2	2
2.1	1	2.1	0	2.1	1	2.1	1

The extreme scenarios - 50 homes/feeder



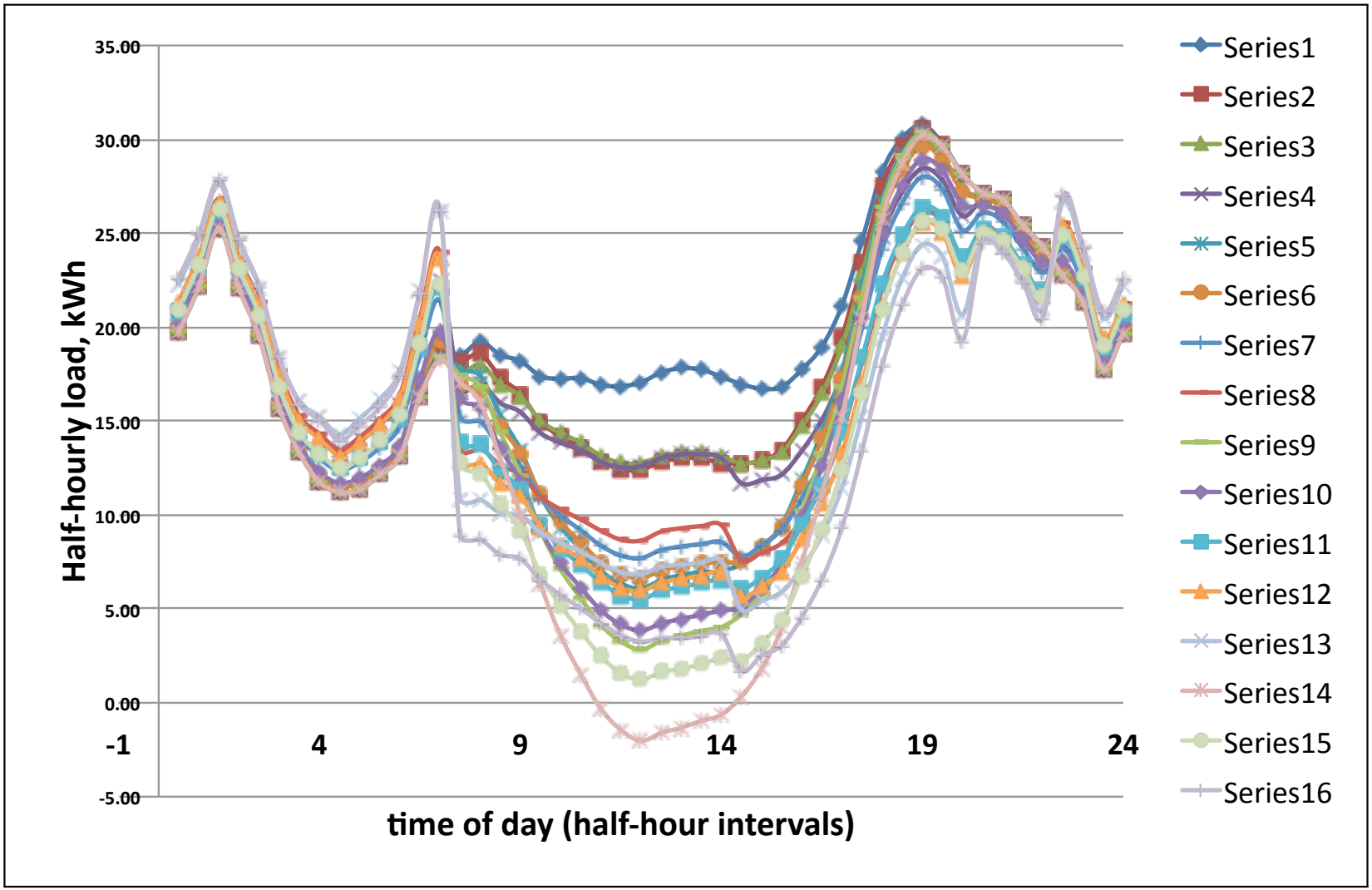
Scenario	PV uptake (%)	Battery uptake (% homes w PV)	Battery uptake (% homes w/o PV)
1	0	0	0
14	100	0	0

The extreme scenarios - incl PV + battery



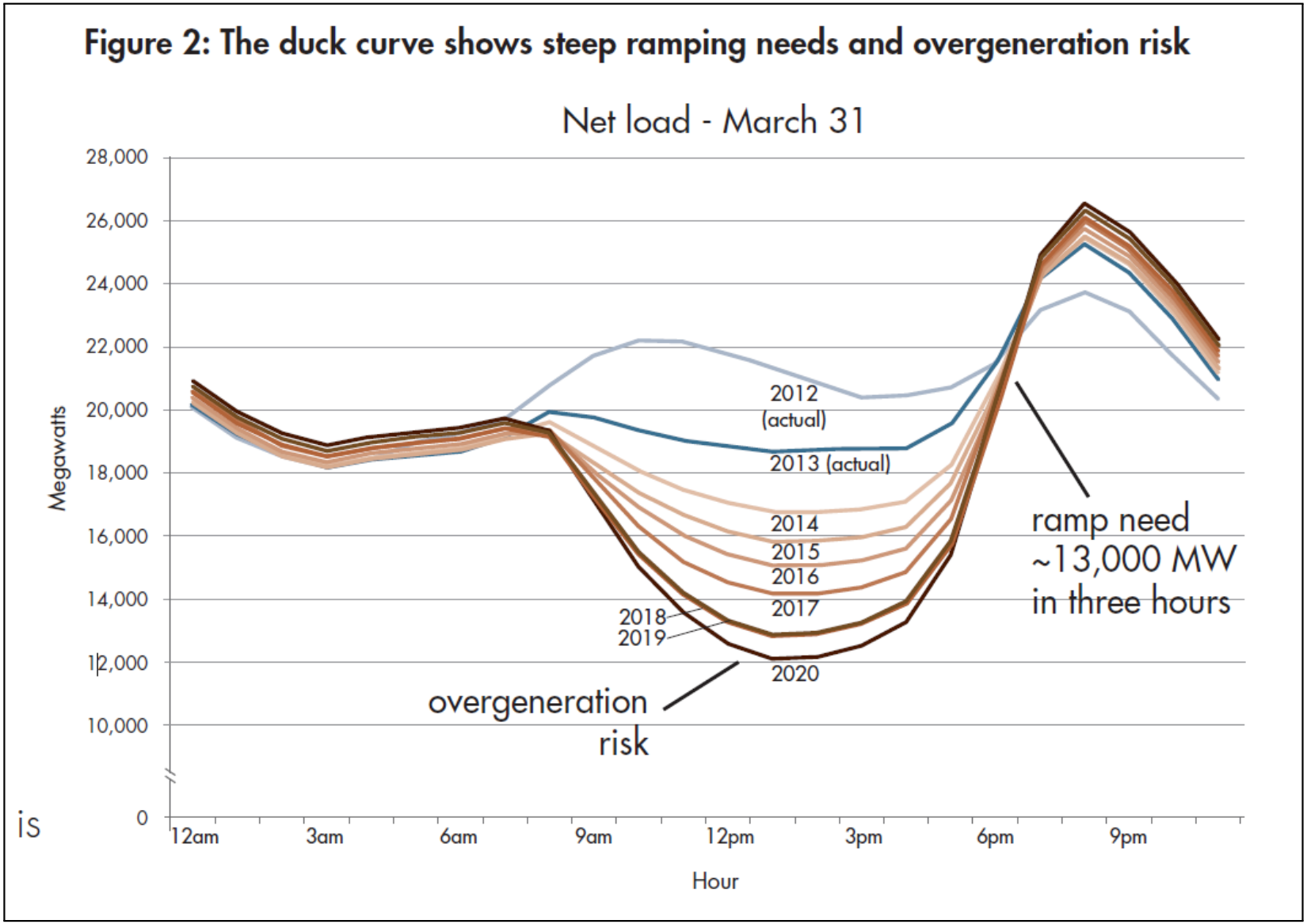
Scenario	PV uptake (%)	Battery uptake (% homes w PV)	Battery uptake (% homes w/o PV)
1	0	0	0
14	100	0	0
16	100	100	0

All 16 scenarios - 1 feeder 50 homes



50 homes/feeder -clustered around North Sydney

The Caliso duck



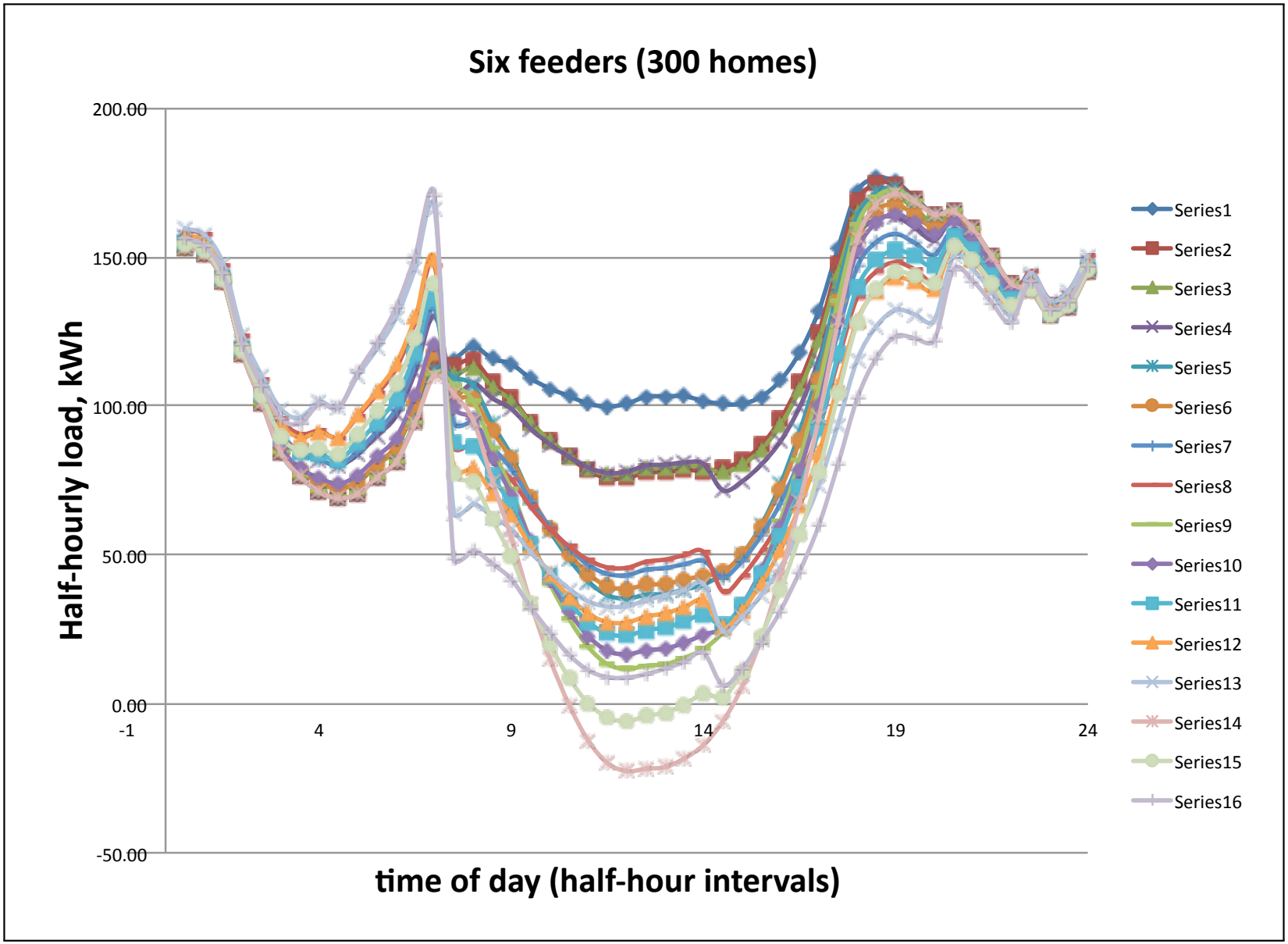
Source: www.caiso.com

Summary of six feeders

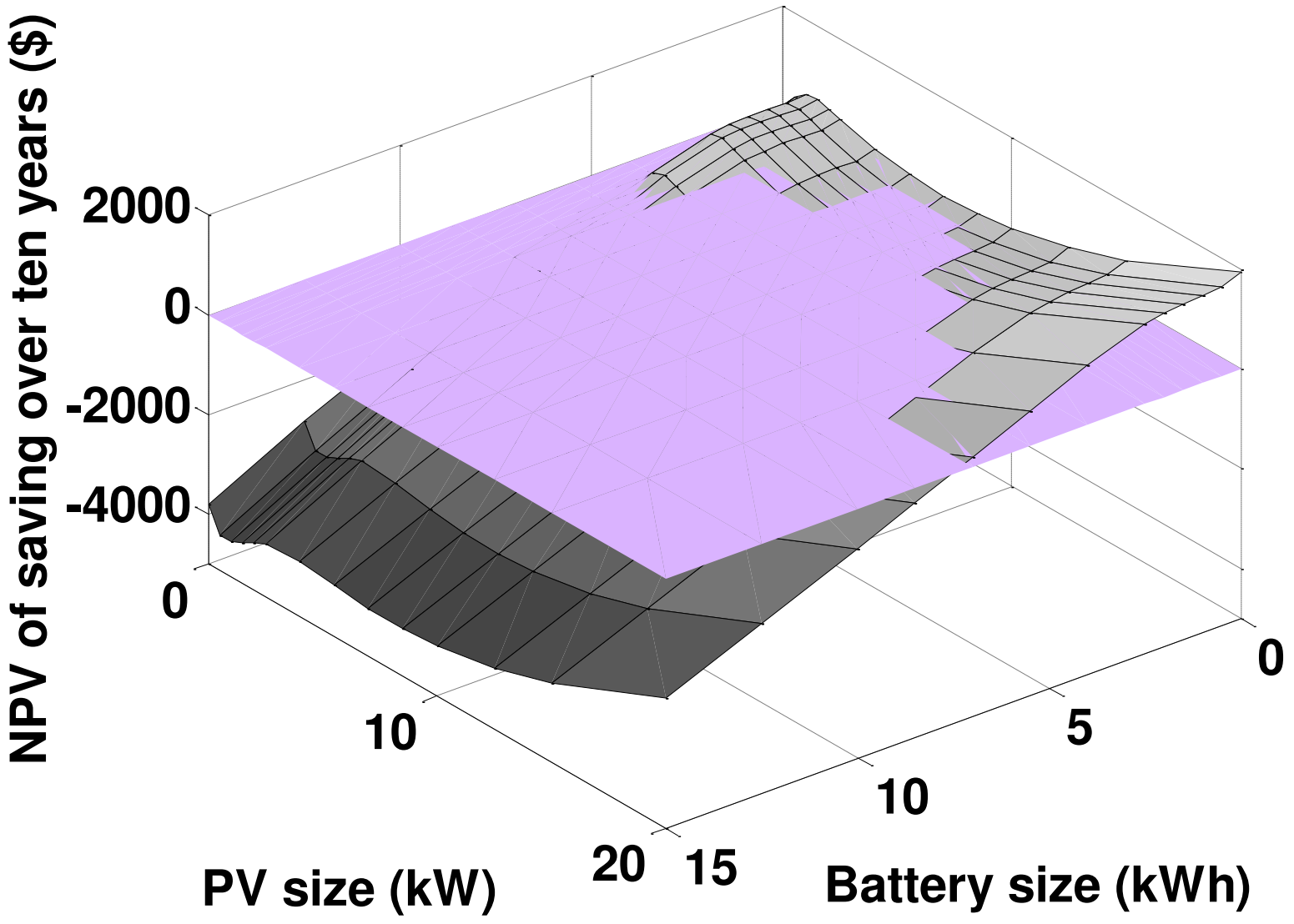
Feeder No	Total PV size (at Scenario 16), kW	Total battery size (at Scenario 16), kWh	No of homes with controlled load	Share of CL in annual load
1	79.01	120	12 (24%)	8.25%
2	82.83	127	17 (34%)	10.96%
3	78.64	117	25 (50%)	15.37 %
4	81.35	120	35 (70%)	19.55 %
5	76.79	115	30 (60%)	14.40 %
6	106.37	161	17 (34%)	5.81 %

Feeder 2 shown earlier, each feeder a different group of 50 homes/region

Six feeders - 300 homes



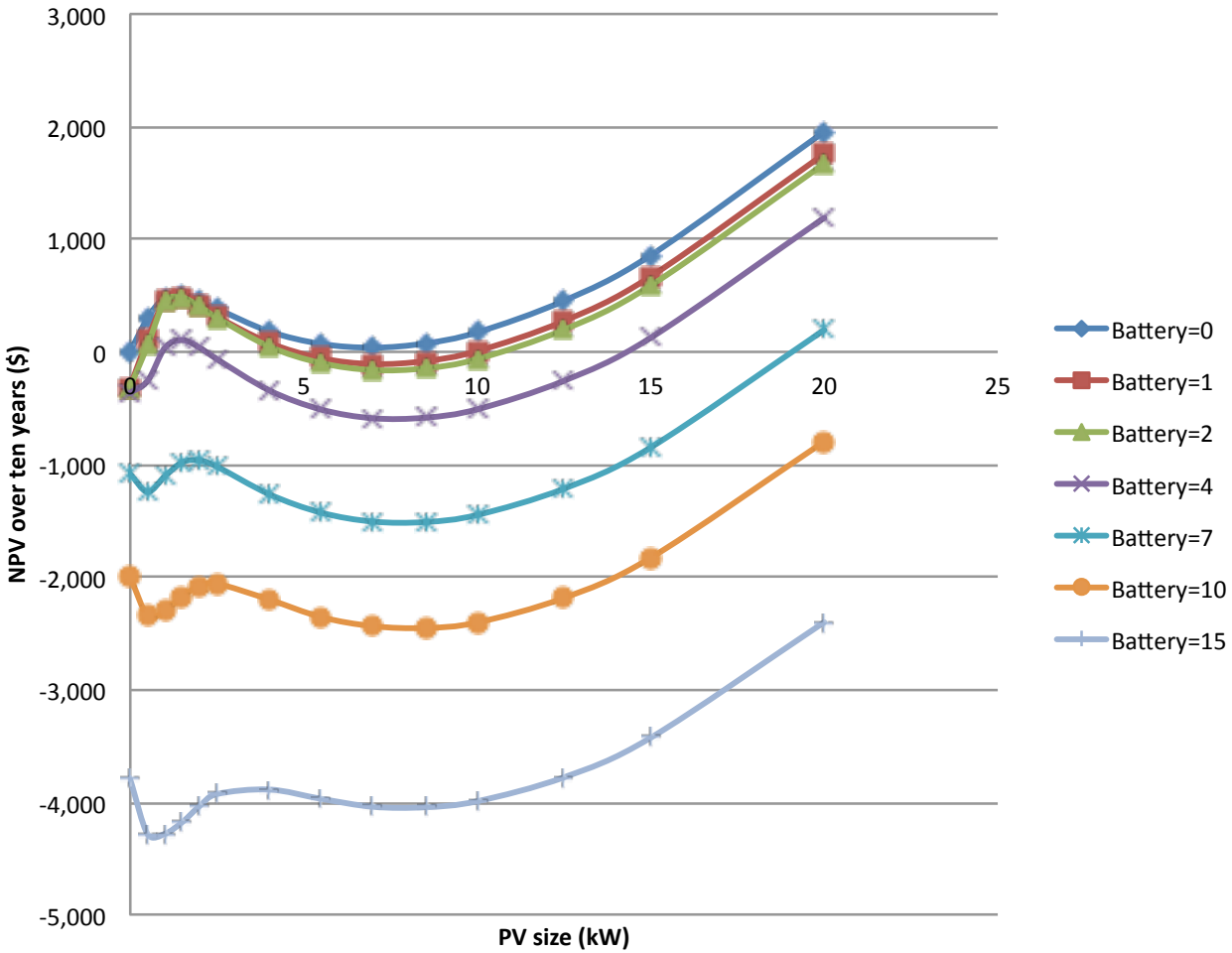
Effect of technology cost and scale - $\sim$ present costs



PV: \$3000/kW, Battery: \$1000/kWh [cost scales as eg $\$3000 * kW^{0.76}$]

Annual consumption 8544.4 kWh; OP:5219.9 kWh, Sh:2307.5 kWh P:1017.0 kWh

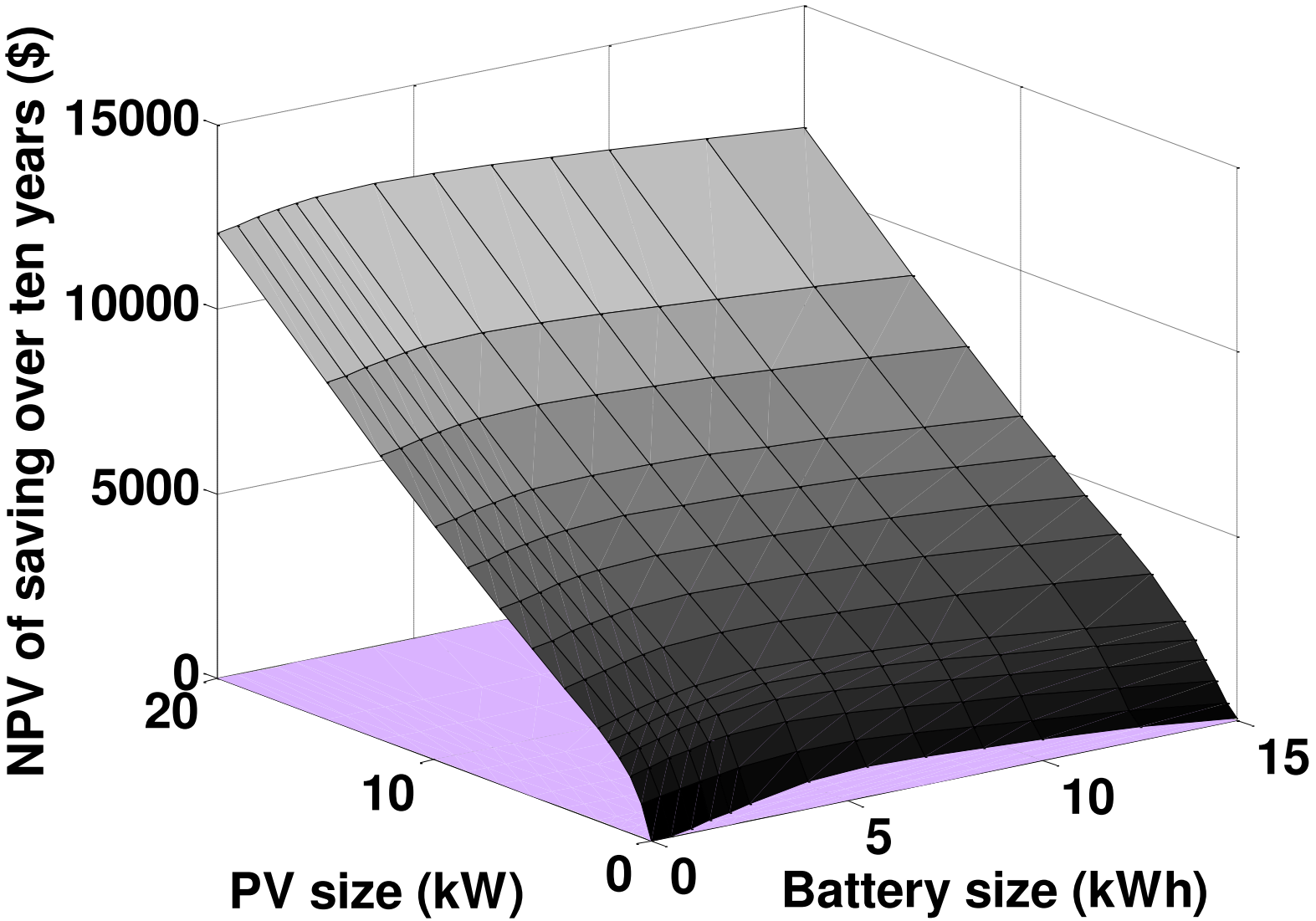
Effect of technology cost and scale



Single home PV:\$3000/kW, Battery: \$1000/kWh

[cost scales as eg $\$3000 * \mathrm{kW}^{0.76}$]

Effect of technology cost and scale $\sim$ "future costs"

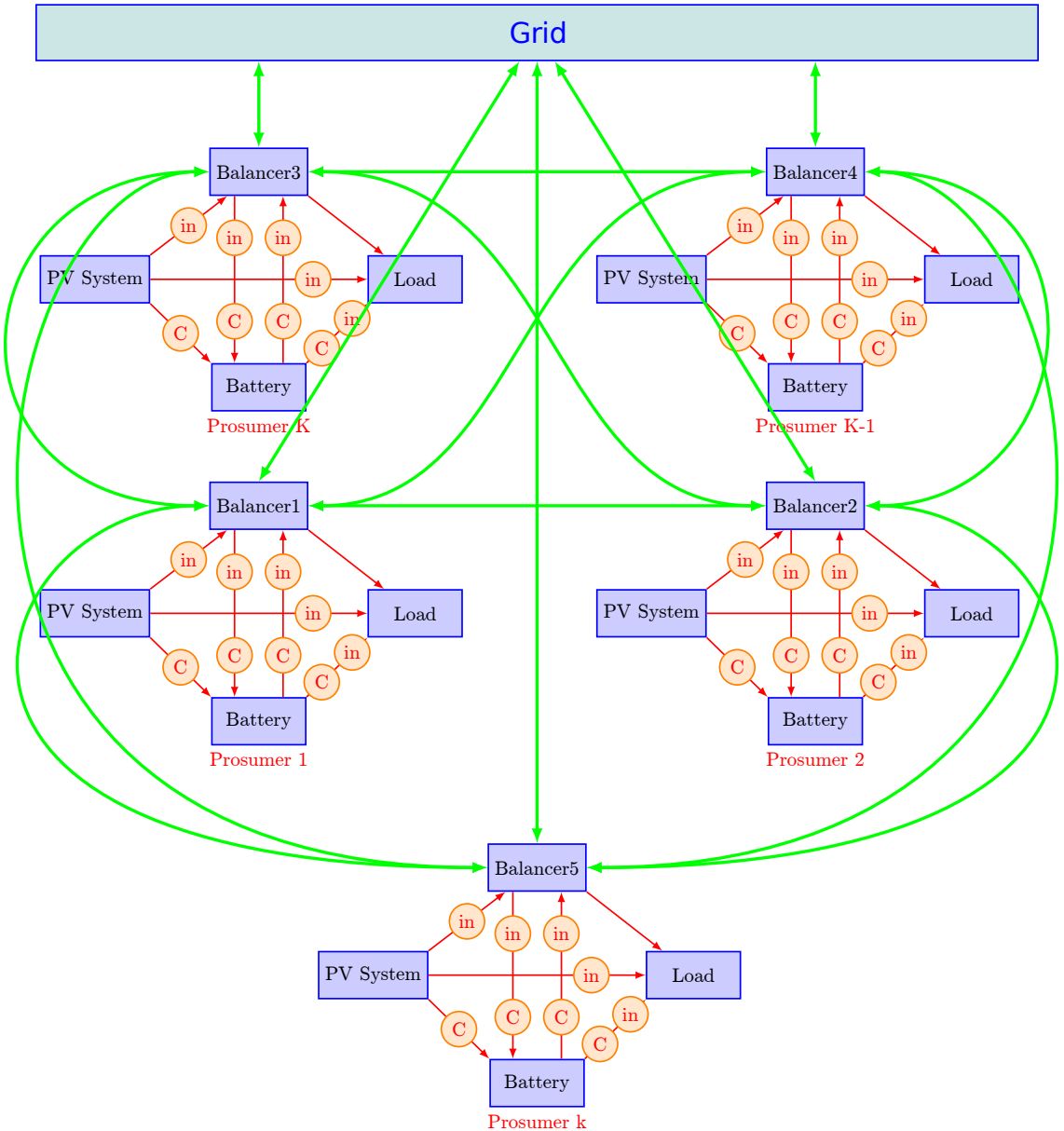


Single home PV:\$1600/kW, Battery: \$400/kWh [cost scales as eg $\$1600 * \text{kWh}^{0.76}$]

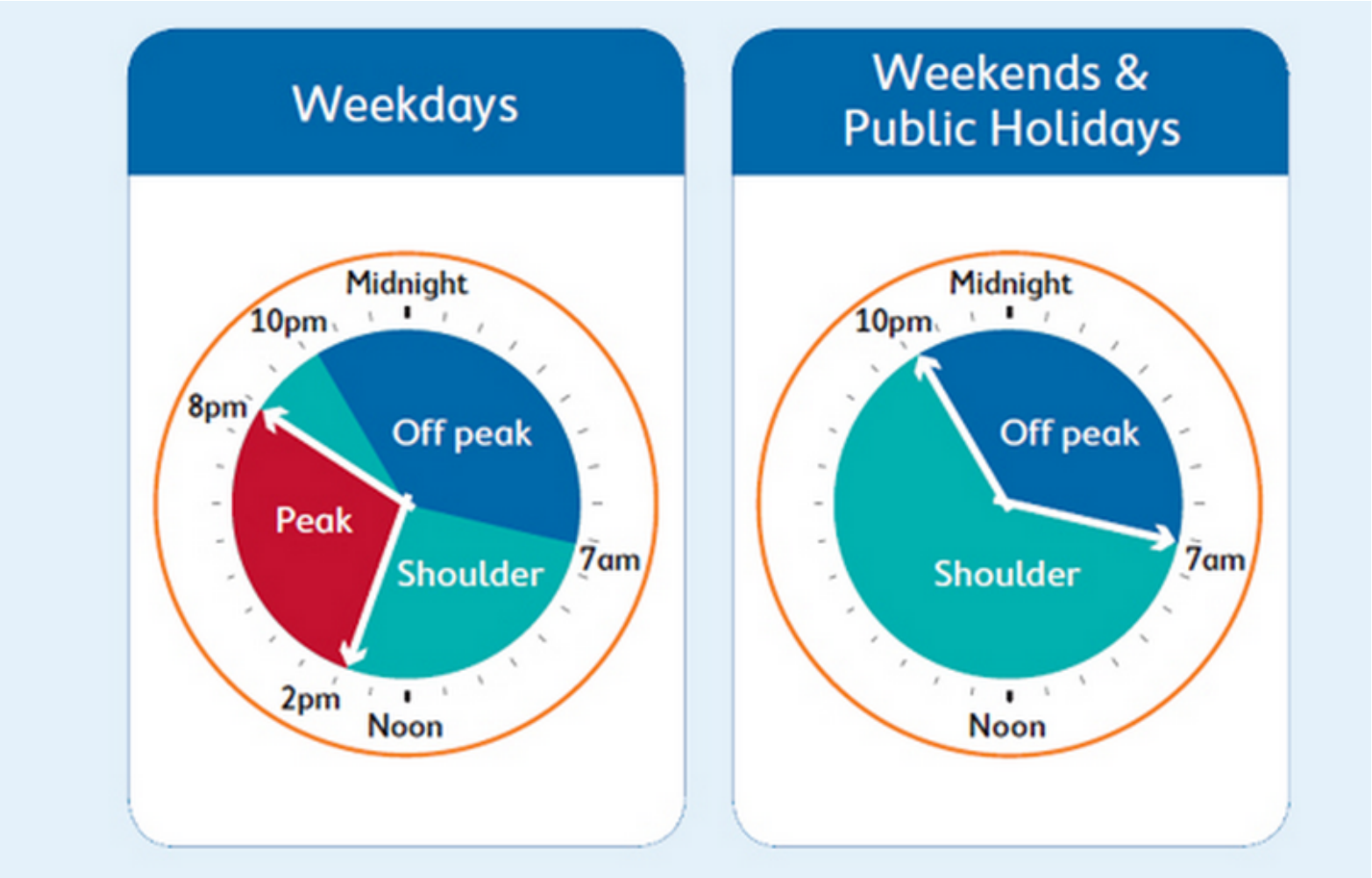
Conclusions

1. ToU and FiT have significant impact on residential load profiles with PV+battery
2. Tariffs with a step function may be problematic for networks with high PV+battery deployment
3. Larger PV systems (resulting from lower costs) will facilitate storage

If the Rules change - Local Energy Markets



ToU example - Ausgrid



source: http://www.ausgrid.com.au/Common/Our-network/Metering/Time-of-use-pricing