MICROGRIDS II

Optimizing Microgrid Selection and Operation for Data Center Sustainability

by

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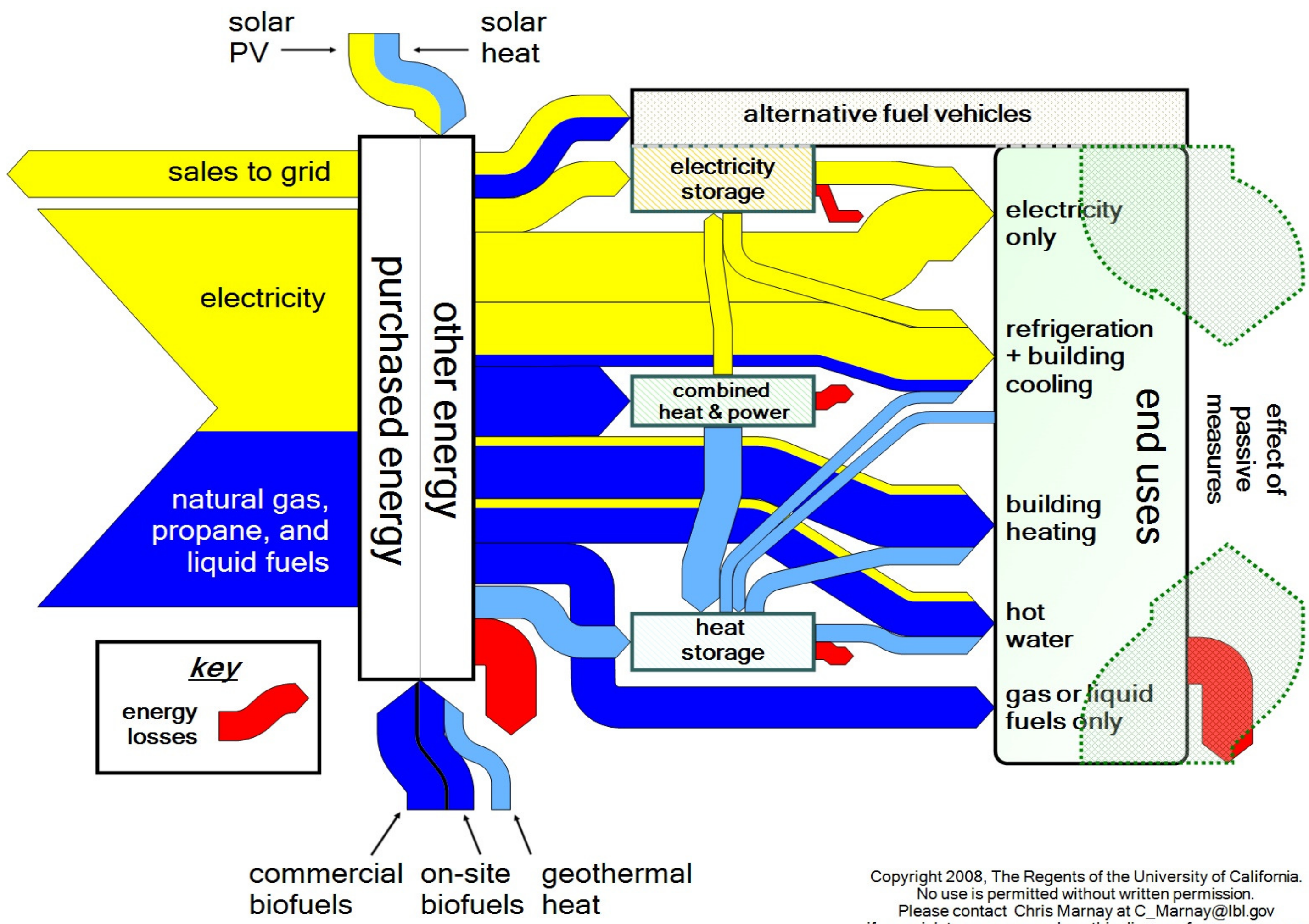
Outline

- systemic analysis of building energy systems
- Distributed Energy Resources Customer Adoption Model
- data center example

DER-CAM Concept



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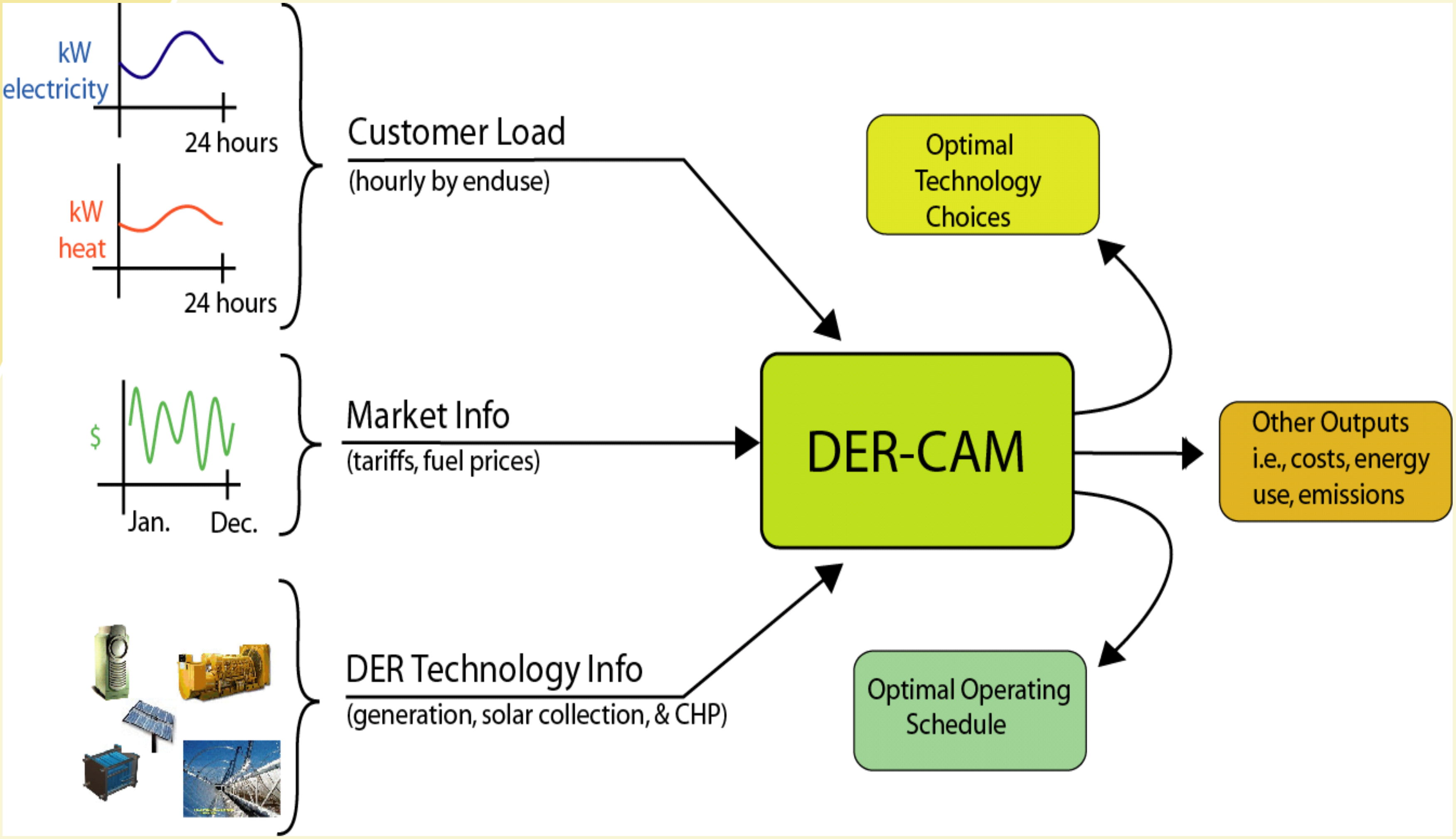
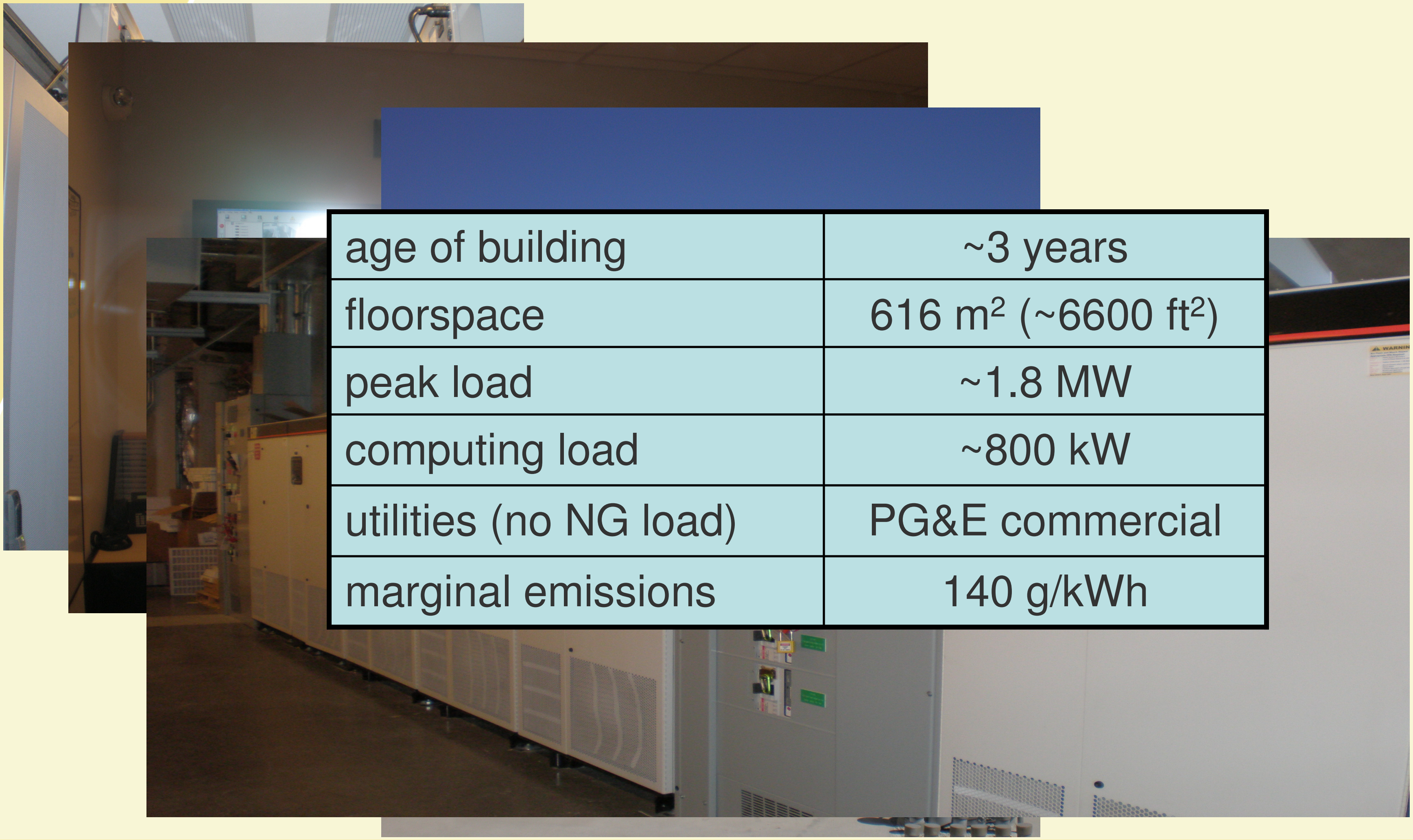
DER-CAM Logic



What is DER-CAM?

- Mixed Integer Linear Program (MILP), written in the General Algebraic Modeling System (GAMS®)
- minimizes annual energy costs (or carbon emissions or multiple objectives) of providing services on a microgrid level (typically buildings 250-2000 kW peak)
- produces pure technology neutral optimal results with highly variable run times
- used for more than 5 years by Berkeley Lab and under license by researchers in the US, Germany, Spain, Belgium, Japan, and Australia

SV Data Center



age of building	~3 years
floorspace	616 m^2 (~6600 ft^2)
peak load	~1.8 MW
computing load	~800 kW
utilities (no NG load)	PG&E commercial
marginal emissions	140 g/kWh

Available Equipment

discrete

	CM-100	fuel cell
capacity (kW)	100	200
sprint capacity	125	
installed costs ($/kW)	2400	5005
with heat recovery ($/kW)	3000	5200
variable maintenance ($/kWh)	0.02	0.029
efficiency (%, HHV)	26	35
lifetime (a)	20	10

only integer installations

continuous

fixed unavoidable costs

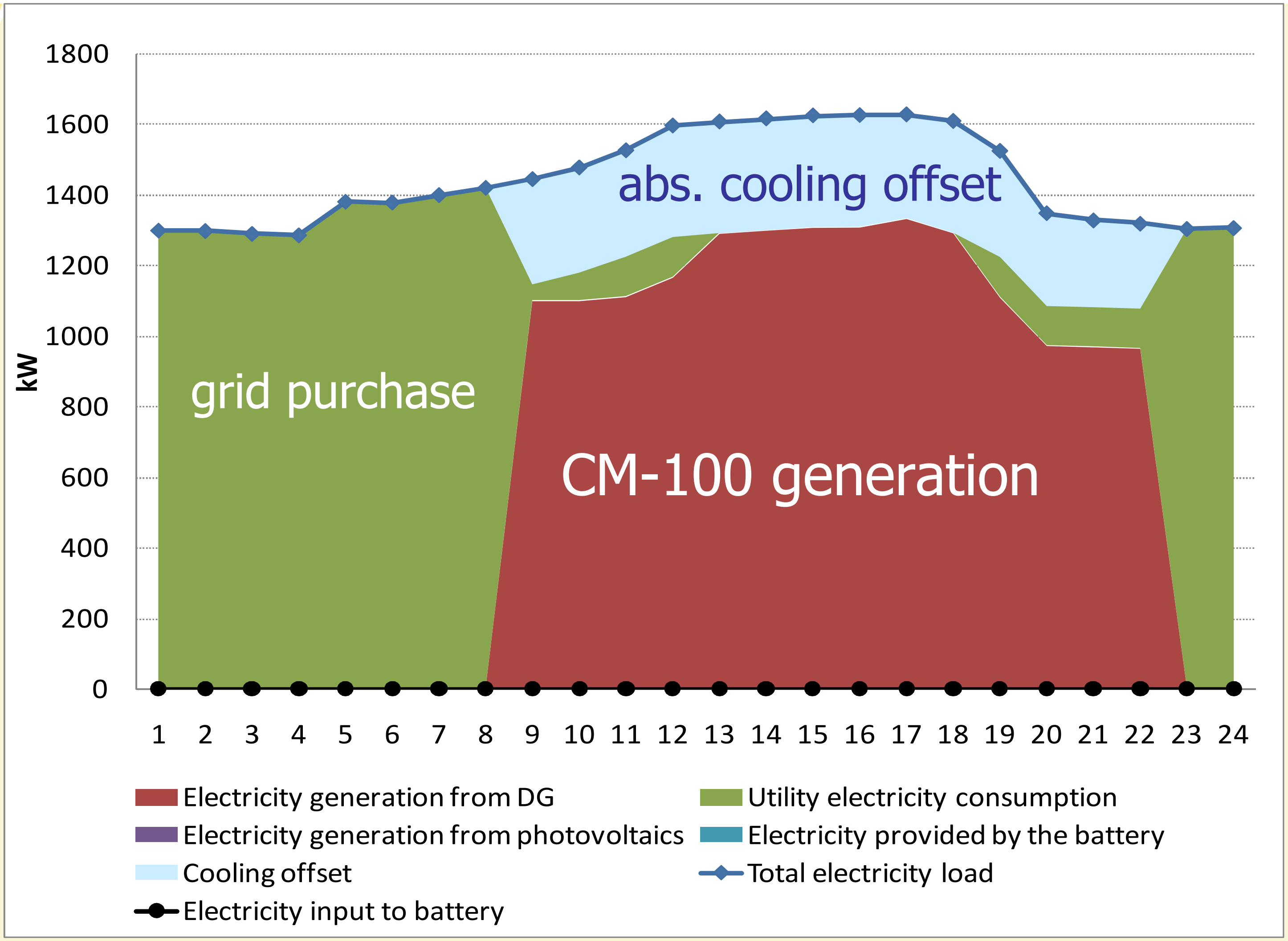
	electrical storage (lead acid)	thermal storage	flow battery	absorption chiller	solar thermal	PV
intercept costs ($)	295	10000	0	20000	1000	1000
capacity ($/kW or $/kWh)	193	100	2125/ 220	127	500	6675
lifetime (a)	5	17	10	15	15	20

Results from 5 Cases

at full current technology costs → B

	A	B	C	D	E
	do nothing	invest in all technologies	low storage costs and PV incentive of 2.5$/W	low storage and PV costs and PV incentive (PV incentive 60%)	(PQR) DER switch run
equipment					
Tecogen 100 kW with HX (kW)	n/a	0	0	0	1600
switch size (kW)		n/a	n/a	n/a	1788
abs. chiller (kW in terms of electricity)		141	108	116	316
solar thermal collector (kW)		0	0	0	0
PV (kW)		0	0	1577	0
Electric storage (kWh)		0	13478	6434	0
thermal storage (kWh)		0	0	0	0
annual costs (k$)					
onsite DG technologies	n/a	3.99	195.51	467.12	249.36
Benefit from switch ($/kW/a)	n/a	n/a	n/a	n/a	125.00
Total	1480.15	1473.18	1442.59	1422.24	1443.10
% savings compared to do nothing	n/a	0.47	2.54	3.91	2.50
annual energy consumption (GWh)					
electricity	11.42	11.39	11.74	8.91	8.44
NG	0.00	0.23	0.15	0.12	9.14
annual carbon emissions (t/a)					
emissions	1598.92	1606.13	1650.98	1253.97	1632.06
% savings compared to do nothing	n/a	-0.45	-3.26	21.57	-2.07

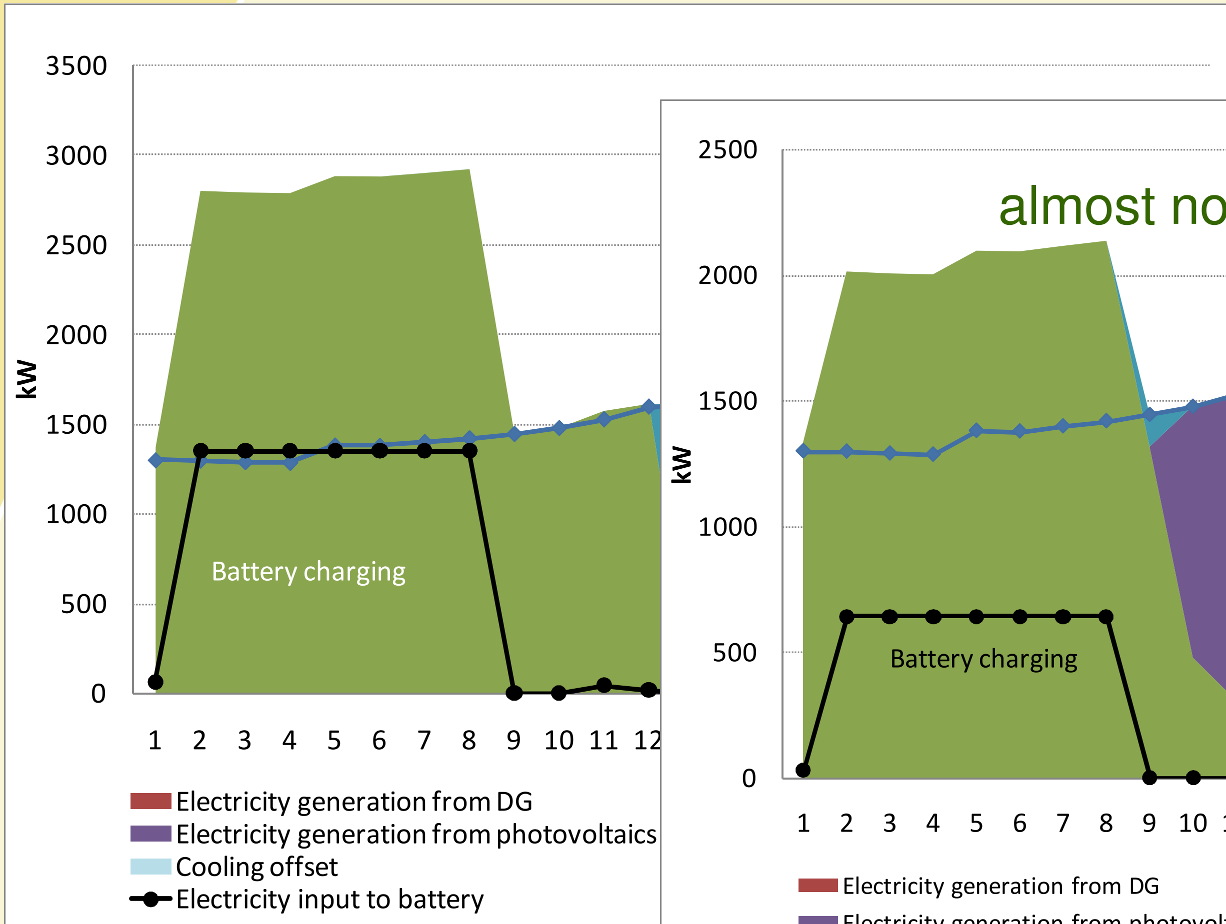
Electricity Balance Case E
(July Weekday)

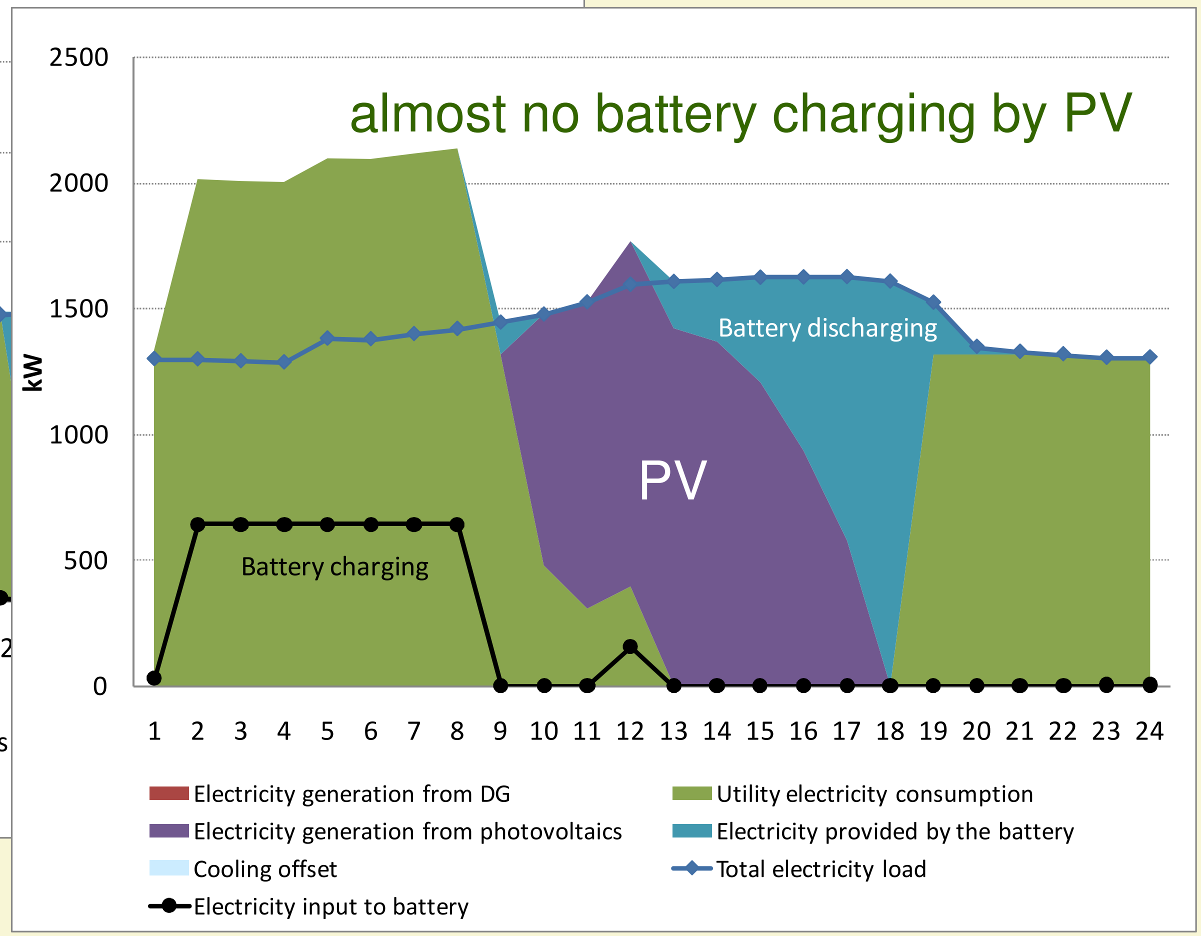


Electricity Balance C & D

(July Weekday)

Case D





Case C

Conclusion

- DER-CAM provides a technology neutral optimal equipment choice & operating schedule under many possible objectives

- analysis of a Silicon Valley data center shows
  → virtually no options cost effective at full current costs
  →lower cost storage and PV subsidies can make them competitive and lower carbon footprint
  → dramatic PQR results at 125 $/kW·a reliability value
  1.6 MW of on-site generation & absorption cooling
  increased carbon footprint (as in most cases)

- DER-CAM approach can be extended to include full? range of technology options and objectives

Thank you!