

# MICROGRIDS



## Relevant LBNL Work on Solar Heating and Cooling

*Chris Marnay*

Ernest Orlando Lawrence Berkeley National Laboratory

[ChrisMarnay@LBL.gov](mailto:ChrisMarnay@LBL.gov) - <http://microgrid.lbl.gov>

*(collaborators: Wei 冯威 Feng, Nicholas DeForest, Judy Lai, Jason MacDonald, Andrea Mammoli, Gonçalo Mendes, Afzal Siddiqui, Michael Stadler, Johannes Thiemann, Nan 周南 Zhou)*

presentation at

**First Task Definition Workshop**

**New IEA Task on New Generation Solar Cooling Systems**

**Paris, 21 Mar 2013**



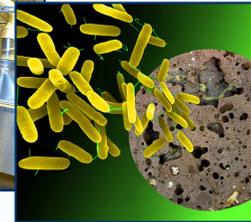
# Berkeley Lab



*Managed by the University of California for the  
United States Department of Energy*



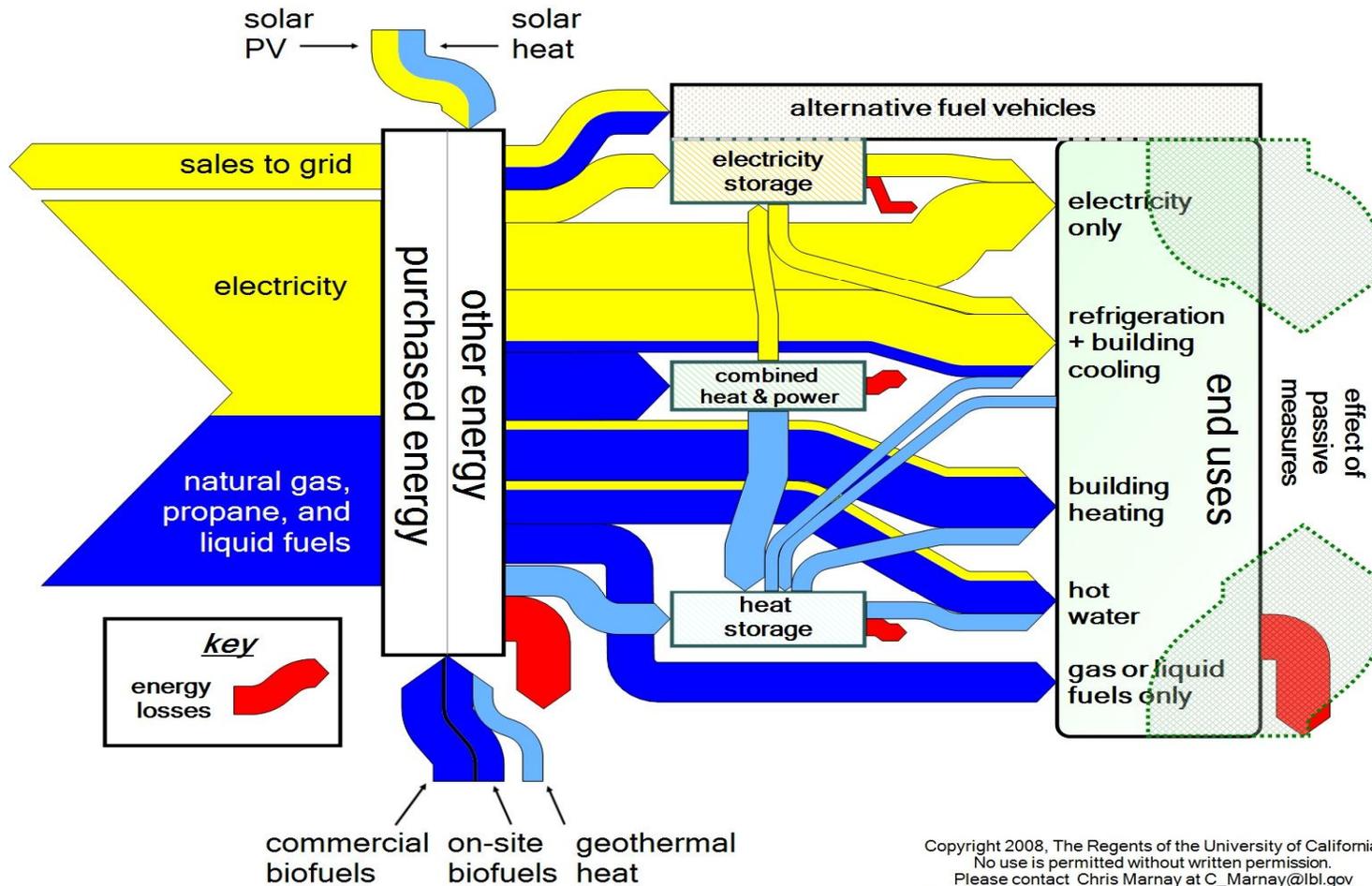
Lawrence Berkeley  
National Laboratory



- 80 ha next to U.C. Berkeley campus, ≈4500 employees, ≈half technical
- broad research areas, & typically ≈600 foreign visitors at any time
  - National Energy Research Scientific Computing Center (NERSC)
  - Joint Genome Institute (JGI), Joint BioEnergy Institute (JBEI)
  - Energy Biosciences Institute (Helios), world's biggest public partnership, etc.
- Environmental Energy Technologies Division
  - broad interdisciplinary research agenda, but with a buildings focus
- Grid Integration Group focused on microgrids, demand response, & storage within Energy Storage and Distributed Resources Dept. with batteries, fuel cells, combustion, etc.



# DER-CAM Concept



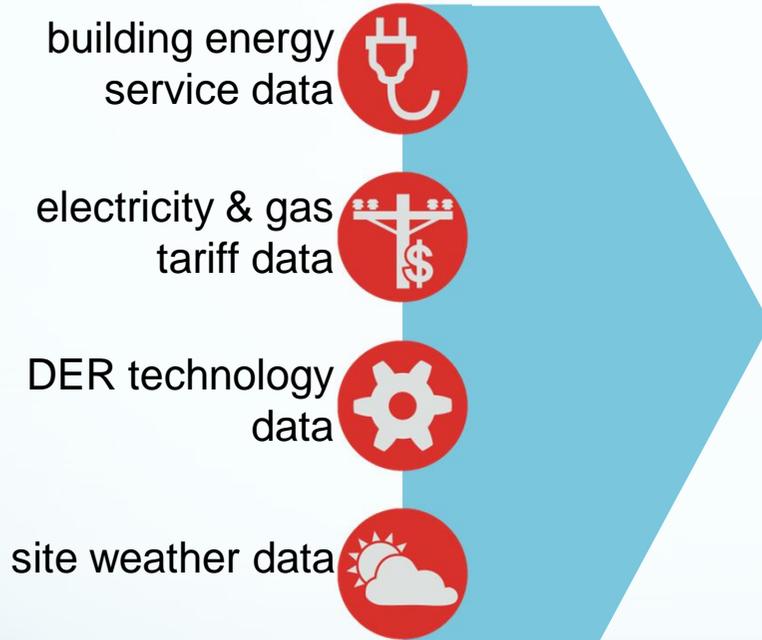
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 Please contact Chris Marnay at C\_Marnay@lbl.gov  
 if you wish to use or reproduce this diagram for any purpose.



# DER-CAM Data Flow

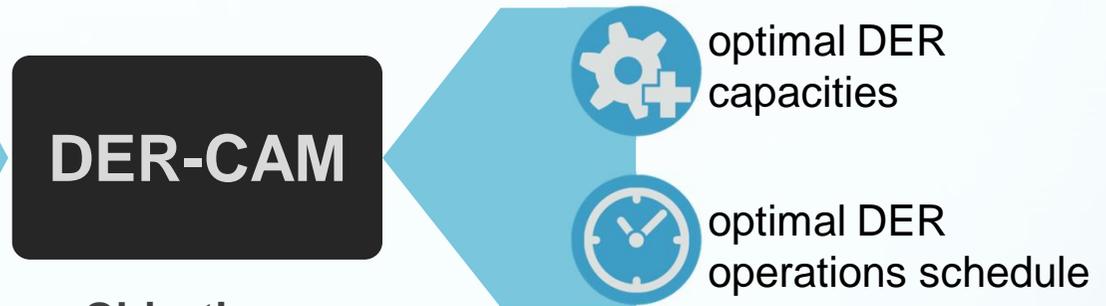


## Inputs:



**Investment & Planning:** determines optimal equipment combination and operation based on *historic* load data, weather, and tariffs

## Outputs:



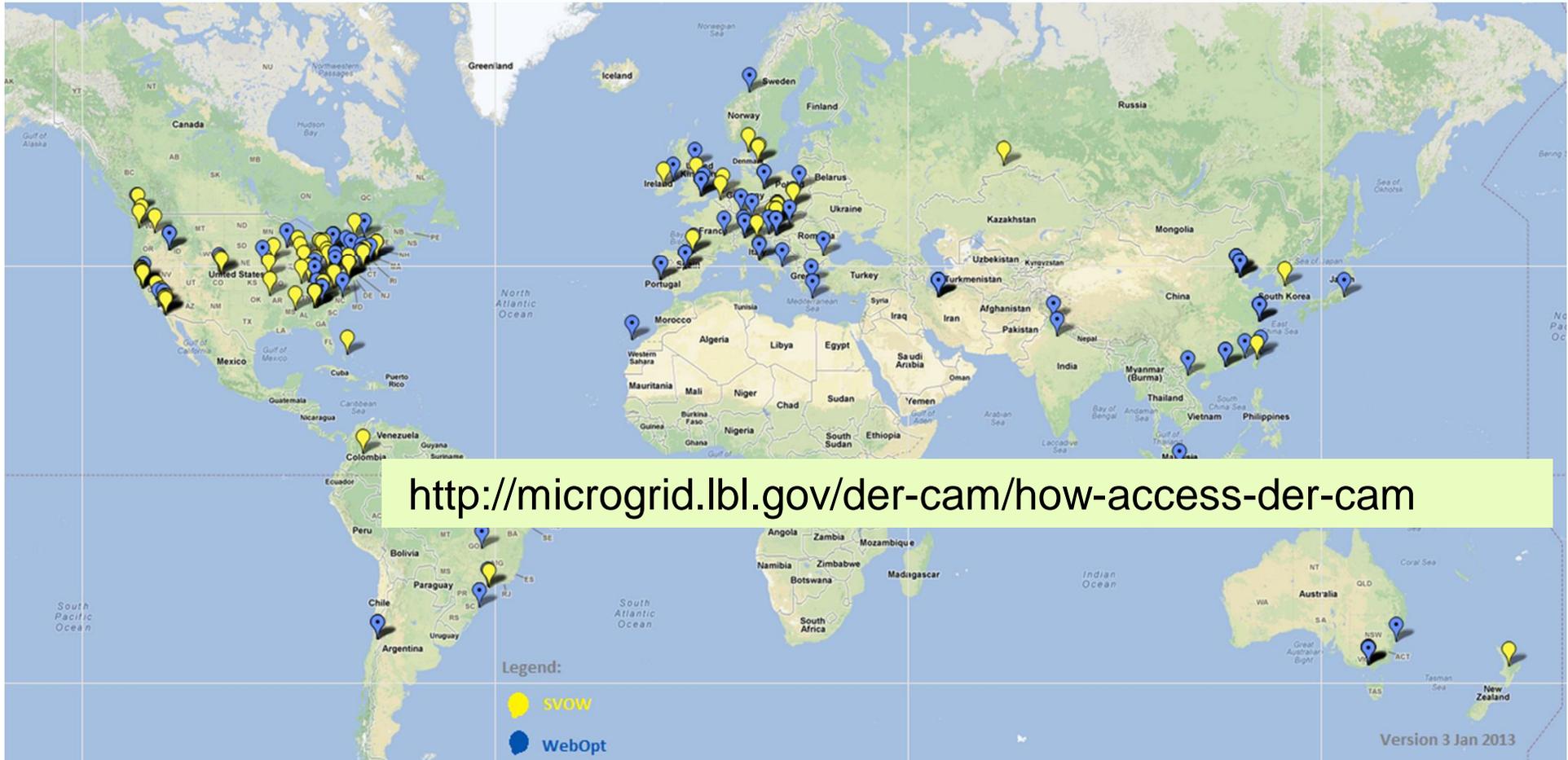
## Objectives:

- Minimize total cost
- Minimize CO<sub>2</sub> emissions

**Operations:** determines optimal week-ahead scheduling for installed equipment and *forecasted* loads, weather and tariffs



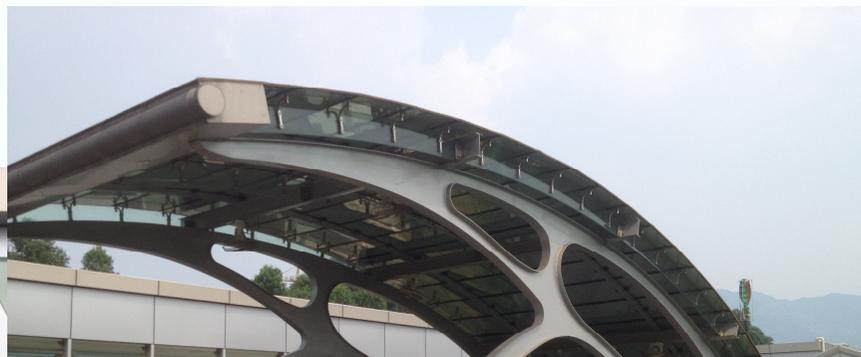
# DER-CAM Users



# UNM Mech. Eng. Bldg.



# XingYe HQ Building, Zhuhai



# Summary



- introduction to Berkeley Lab

- interest in new task

  - inputs from A, other technology performance, building loads, tariffs, etc.

  - produce optimal equipment fleets and operating schedules

  - B2: control strategy analysis & optimisation (also B1 & B5, C & D)

- ongoing R&D

  - control of UNM Mech. Eng. Building, and others in Albuquerque (Prof. Andrea Mammoli partner)

  - collaboration with Chinese researchers on solar applications

  - optimisation of microgrids generally

- input and responsibilities to task

  - optimisation of complex mixed systems

  - analysis of single buildings, or market assessment

  - actual closed-loop building control demonstration

  - analysis in support of dissemination

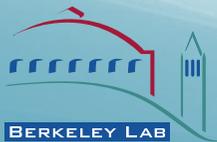




# Thank you!

<http://microgrid.lbl.gov>

<http://www.youtube.com/watchv=3XuCJBvq6Sk>



# Lawrence Introduces Big Team Science

## LBL: The First DOE National Laboratory



# 13 Nobel Prizes



Luis W. Alvarez



Melvin Calvin



Owen Chamberlain



Steven Chu



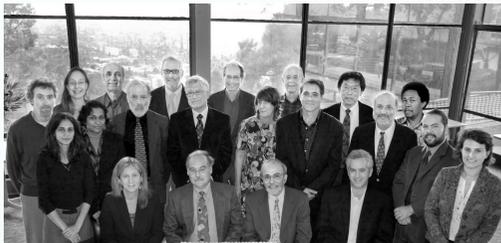
Donald A. Glaser



Ernest Orlando Lawrence



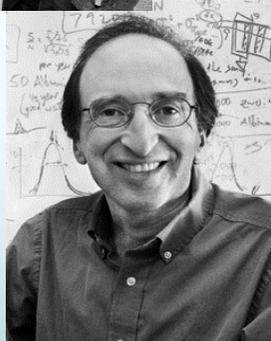
Yuan T. Lee



Intergovernmental Panel on Climate Change (IPCC)



Edwin M. McMillan



Saul Perlmutter



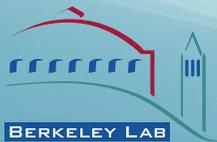
Glenn T. Seaborg



Emilio G. Segrè



George F. Smoot



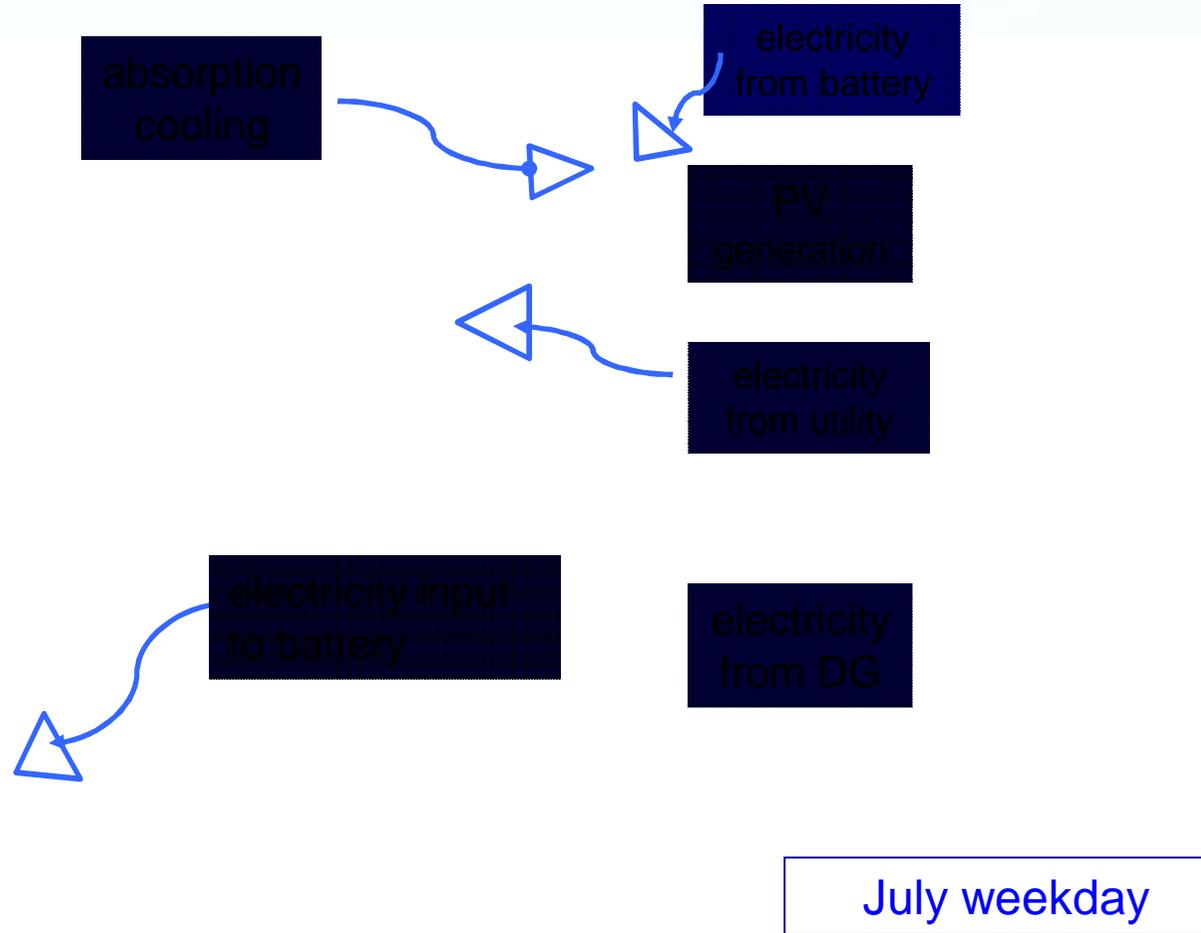
# CO<sub>2</sub> Min. of a S.F. Hospital



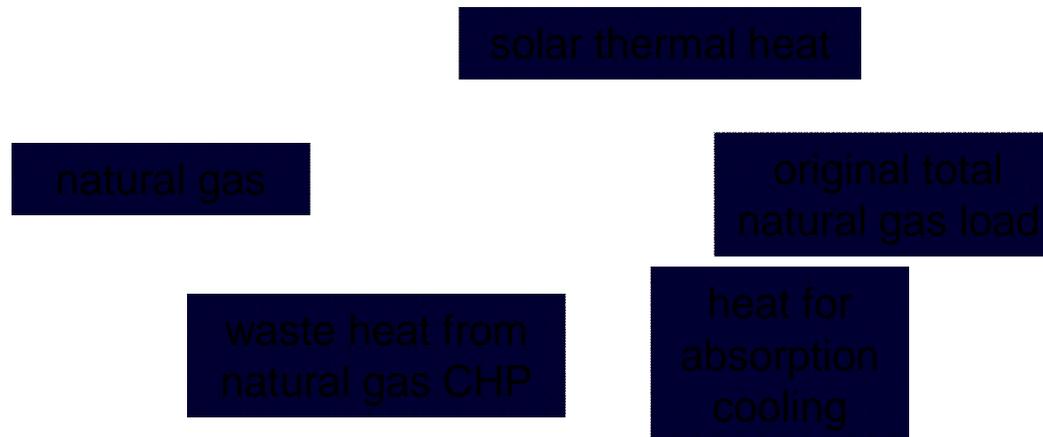
- large San Francisco health care building  
1.8 MW peak, 11 GWh/a
- flat loads, typical diurnal minimum  $\approx$ 800 kW, 70% CF
- CO<sub>2</sub> minimizing lowers footprint by 39%
- 1.42 MW CHP (4 x 250 & 7 x 60), 404 kW PV
- 742 kWh bat., 265 kWt solar thermal
- 180 k\$ or 9% increase in annual energy bill
- limited by solar area constraint & clean grid power



# Electricity Balance



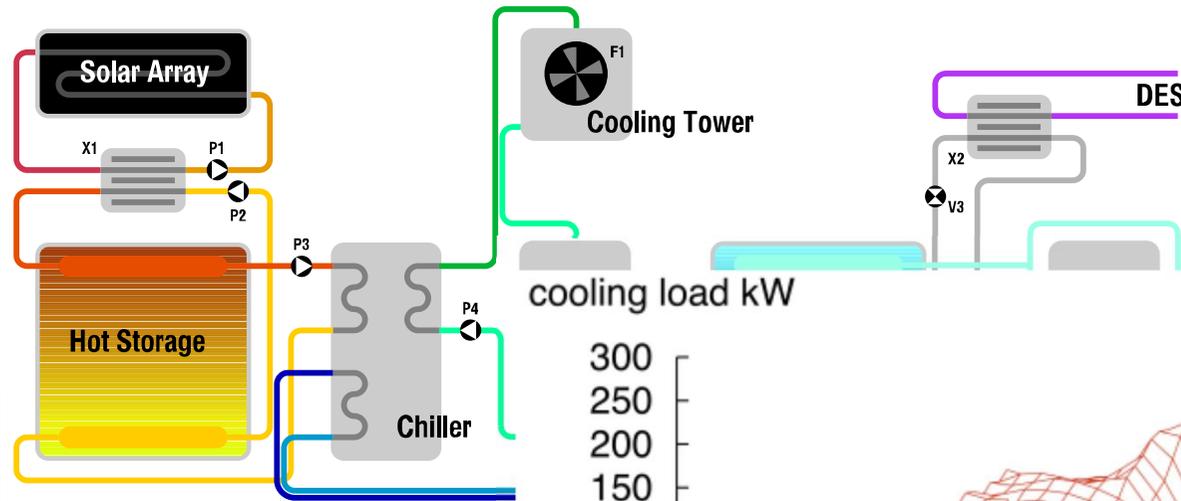
# Heat Balance



July weekday

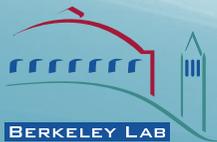
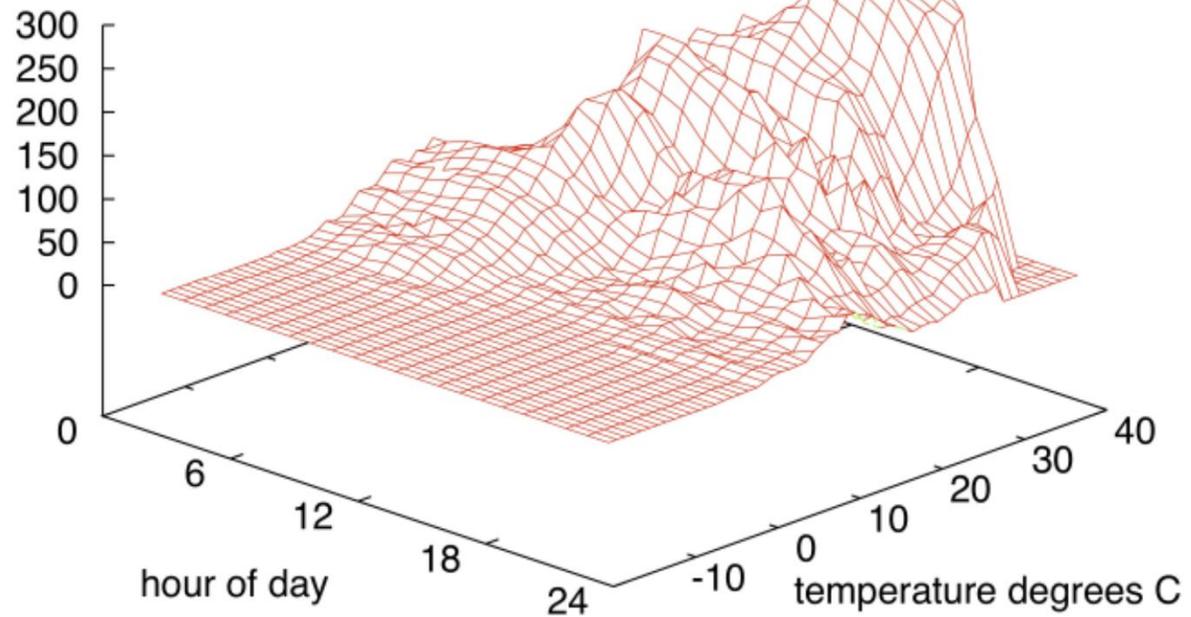


# UNM ME Building Thermal System

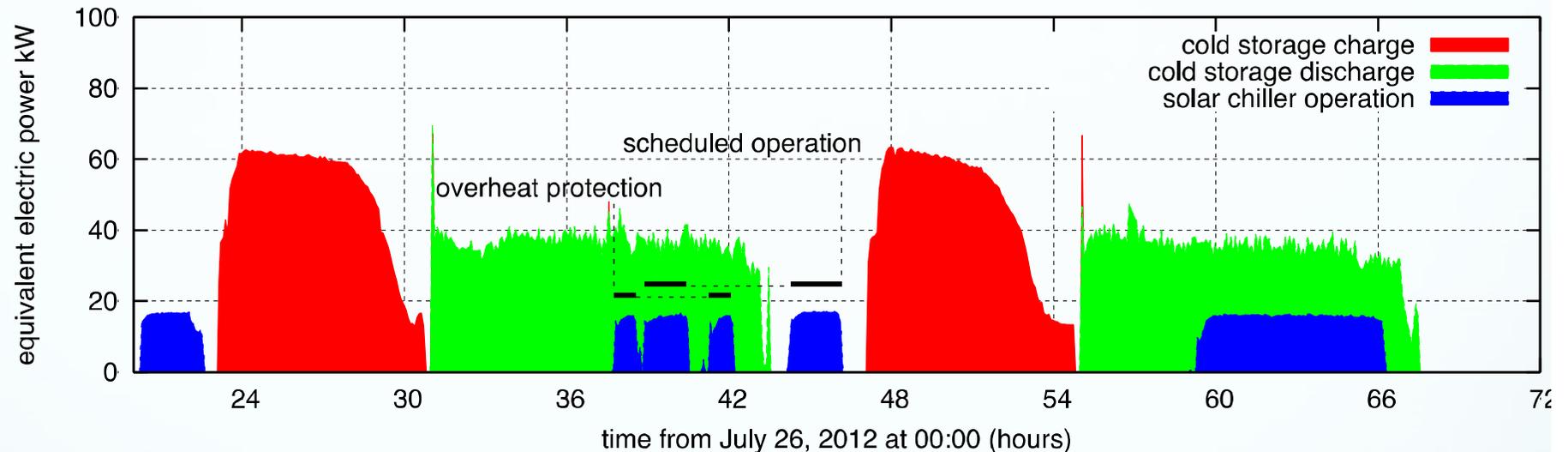


- P1 solar loop glycol pump - variable speed < 4.5 kW
- P2 solar water pump - variable speed < 0.8 kW
- P3 absorber heat medium pump - variable speed < 0.8 kW
- X1 solar heat exchanger
- P4 cooling water pump - variable speed < 4.5 kW
- P5 primary chiller pump - variable speed < 0.8 kW
- P6 absorber heat medium pump - variable speed < 0.8 kW
- X2 DES heat exchanger

cooling load kW



# Scheduling Comparison



- **Alternate weeks used standard scheduling and Operations DER-CAM**  
schedules not dramatically different  
use of absorption chiller is different  
already low costs reduced by 30%



# Investment & Planning (WebOpt)



Distributed Energy Resources (DER) Web Optimization Service (WebOpt)

File Edit Help

Run optimization

GO

Overview/Optimization Settings Load Profiles Utility Tariffs Technologies Demand Response Solar Radiation Marginal CO2 Macrogrid Results

**Optimization Settings**

Investment in DER

- NG powered DER and CHP
- Electric storage
- Heat storage
- Absorption chiller
- Absorption refrigeration
- PV
- Solar thermal
- Demand response
- Air source HP
- Ground source HP
- Existing electric chiller

Do-nothing (no investments, all energy will be bought from the utility and used in the existing natural gas boiler as well as electric chiller)

Consider and show pay-back period in the result file

Show advanced input options

**Advanced Input Options**

Interest rate for investments: 6 % Max. available space for PV system at site: 3000 m2

Max. allowed annual energy costs (including annualized capital costs): 99 mill\$

Max. pay-back period for investments: 12 years

**Optimization Objective**

Cost minimization

CO2 minimization

Please note that with a CO2 minimization strategy the maximum possible PV area at the site and the maximum annual energy bill are very frequently the binding constraints in the optimization. Please check "Show advanced input options" and change the advanced input options if needed.

Discard all changes

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Ready

DER-CAM Web-Service for natural gas fired CHP, PV, solar thermal, electric storage, heat pumps, and absorption chillers

➤ no direct EMS coupling / feedback

Distributed Energy Resources (DER) Web Optimization Service (WebOpt)

File Edit Help

Run optimization

GO

Discard all changes

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Ready

Size of Photovoltaic (m <sup>2</sup> )	0.0
Electricity Generated Onsite (kWh/a)	380,335.5
Utility Electricity Consumption (kWh/a)	507,378.3
Utility Natural Gas Consumption (kWh/a)	1,552,376.9
Total Fuel Consumption (onsite plus fuel for macrogrid electricity, without diesel) (kWh/a)	3,044,686.1
Efficiency of Entire Energy Utilization (Onsite and Purchase), without NG-only load	0.5
Achieved SGIP CHP efficiency	

Please select the month: August Please select the day type: week

Legend:

- Original Electricity Load (inclusive cooling)
- Flow Battery Charging
- Regular Battery Charging
- Flow Battery Discharging
- Regular Battery Discharging
- Refrigeration Electric Load
- Offset from Absorption Chillers
- Building Cooling Electric
- Load Offset from Absorption Chillers
- Electricity from PV
- Utility Electricity Purchase
- Electricity from DG (no PV)

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<http://microgrid.lbl.gov/der-cam/how-access-der-cam>





# Operations DER-CAM Data Flow

