Title

Web-Based Economic and Environmental Optimization of Microgrids

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Environmental Energy Technologies Division

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http://eetd.lbl.gov/EA/EMP/emp-pubs.html

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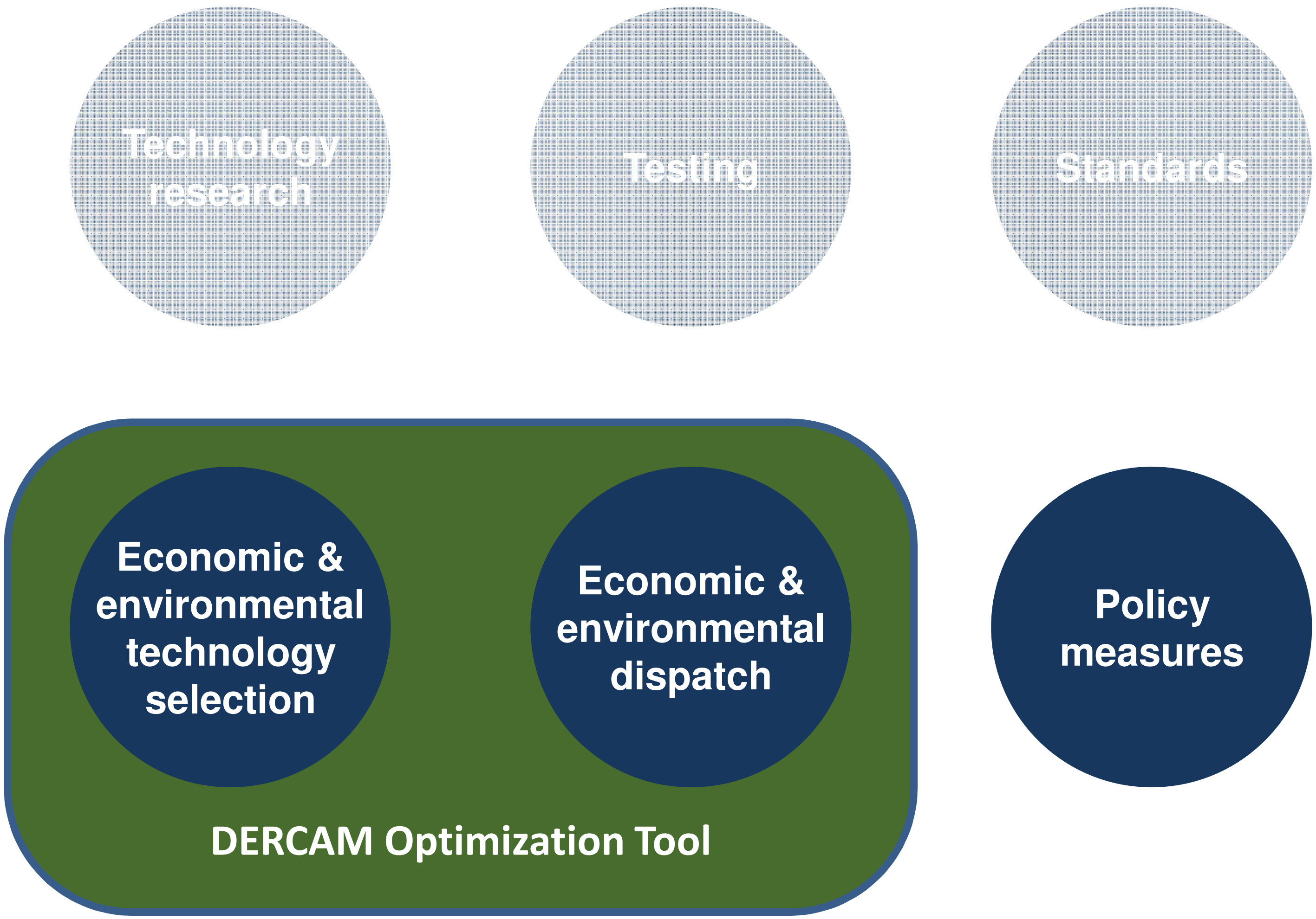
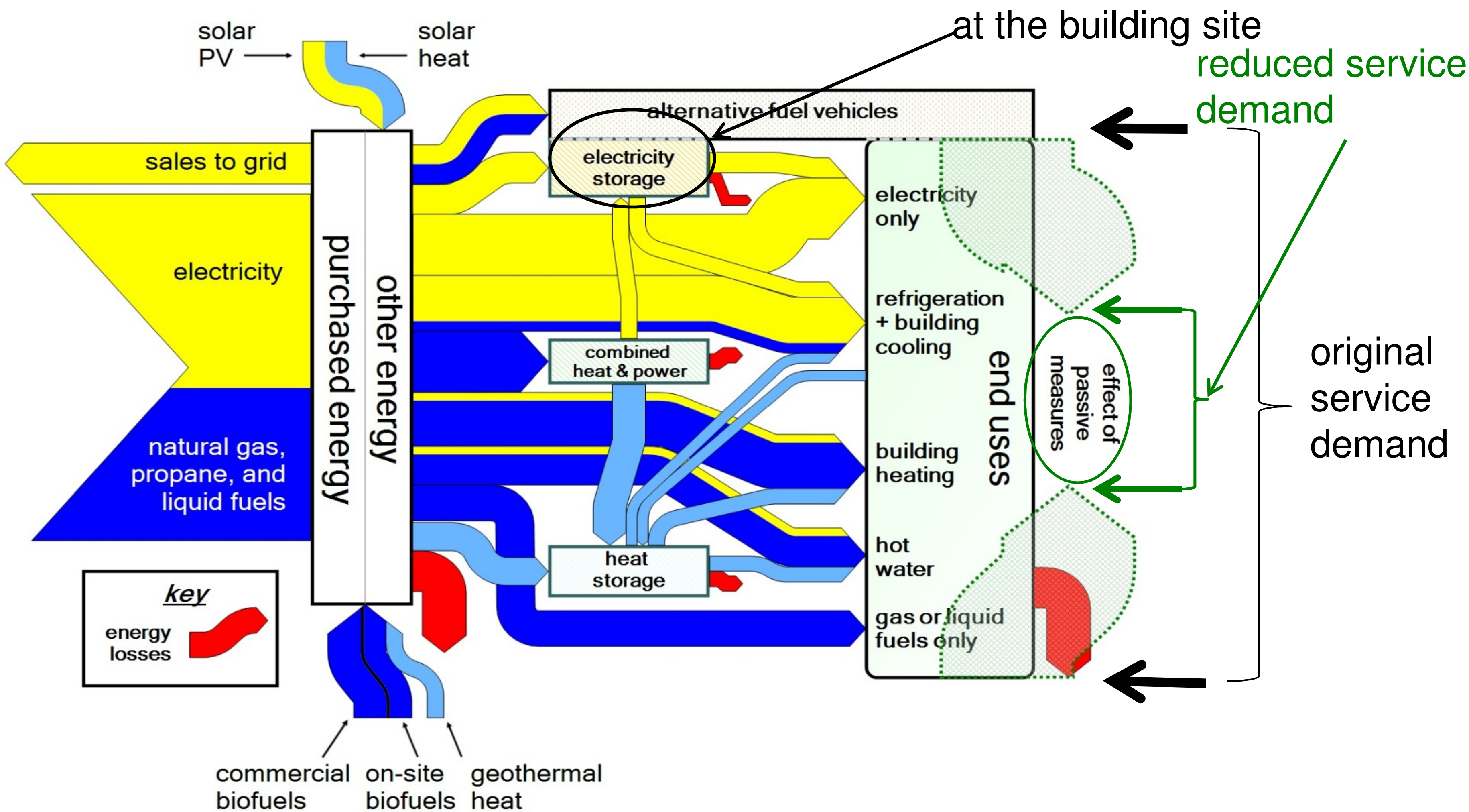
Outline

- Our contribution to microgrids / global concept
- What is DER-CAM?
- Web-Opt: connecting clients to DER-CAM
- Example applications
  – AEP test-bed: Columbus, OH
  – Santa Rita Jail: Dublin, CA
  – University of New Mexico: Albuquerque, NM
- Further/Future Work

Our Contribution to Microgrids



Global Model Concept for Microgrids



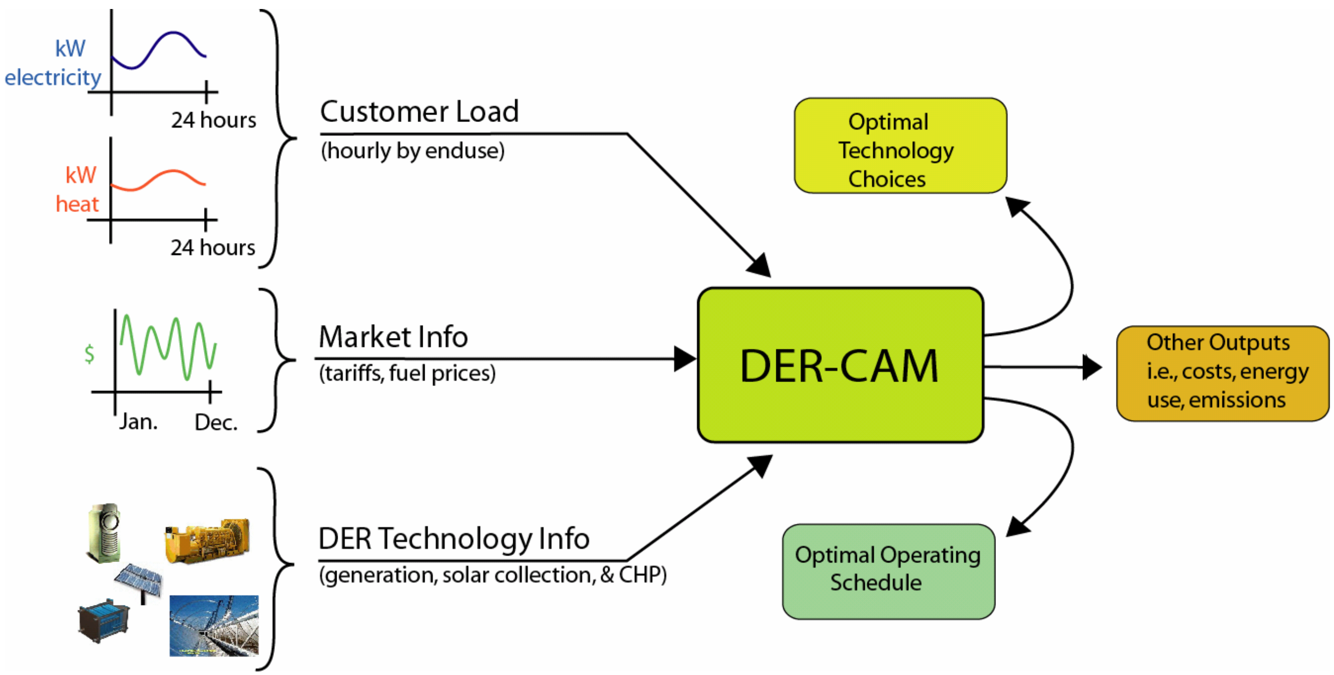
What is DER-CAM

Distributed Energy Resources Customer Adoption Model (DER-CAM)

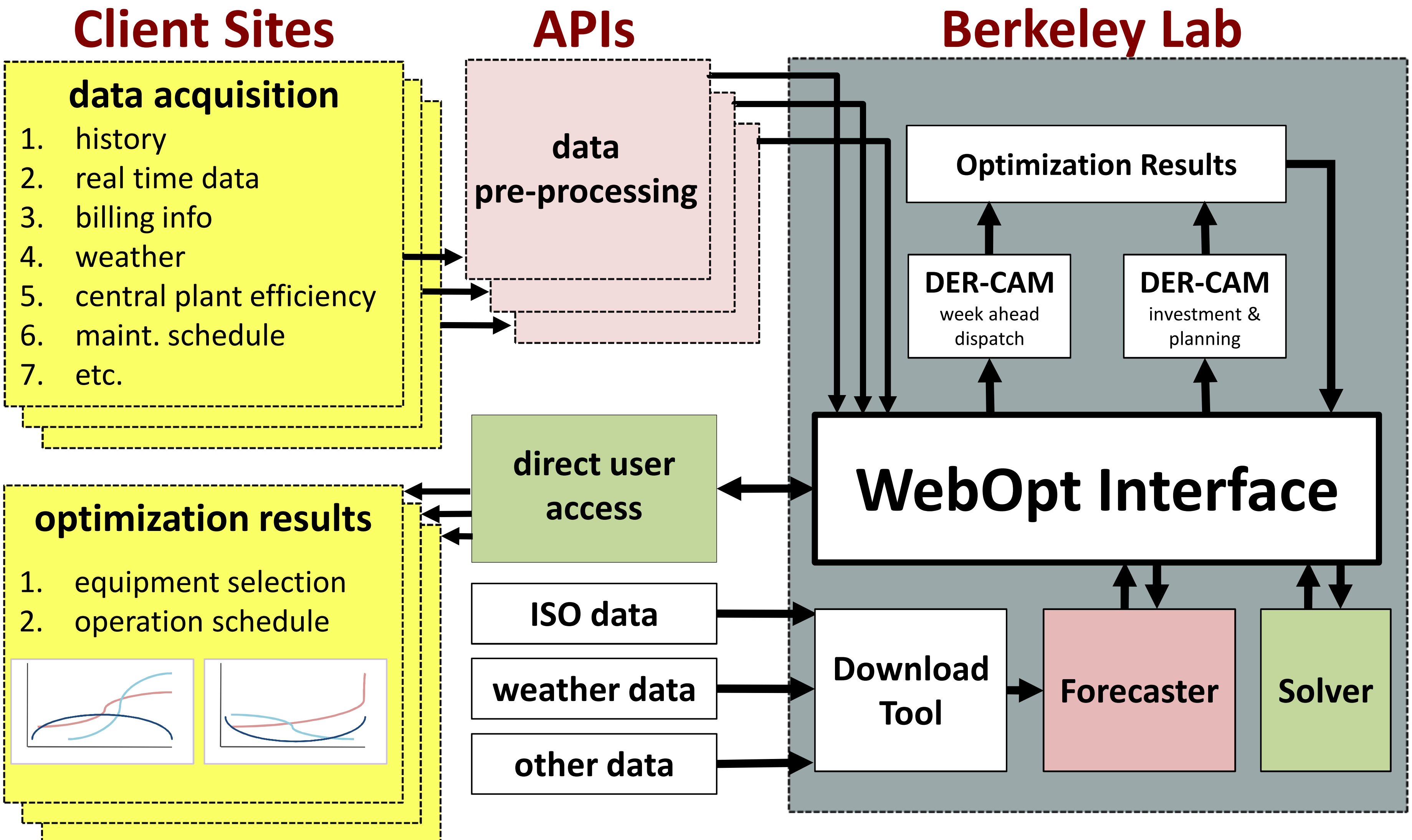
- is a deterministic Mixed Integer Linear Program (MILP), written in the General Algebraic Modeling System (GAMS®)
- minimizes annual energy costs, CO_2 emissions, or multiple objectives of providing services on the building level (typically buildings with 250-2000 kW peak)
- produces technology neutral pure optimal results with highly variable runtime
- has been designed for more than 10 years by Berkeley Lab and collaborations in the US, Germany, Spain, Belgium, Japan, and Australia → exchange visitors
- first commercialization (*web clients*) and real-time optimization steps
- 270 DER-CAM *web clients* to date

DER-CAM Versions

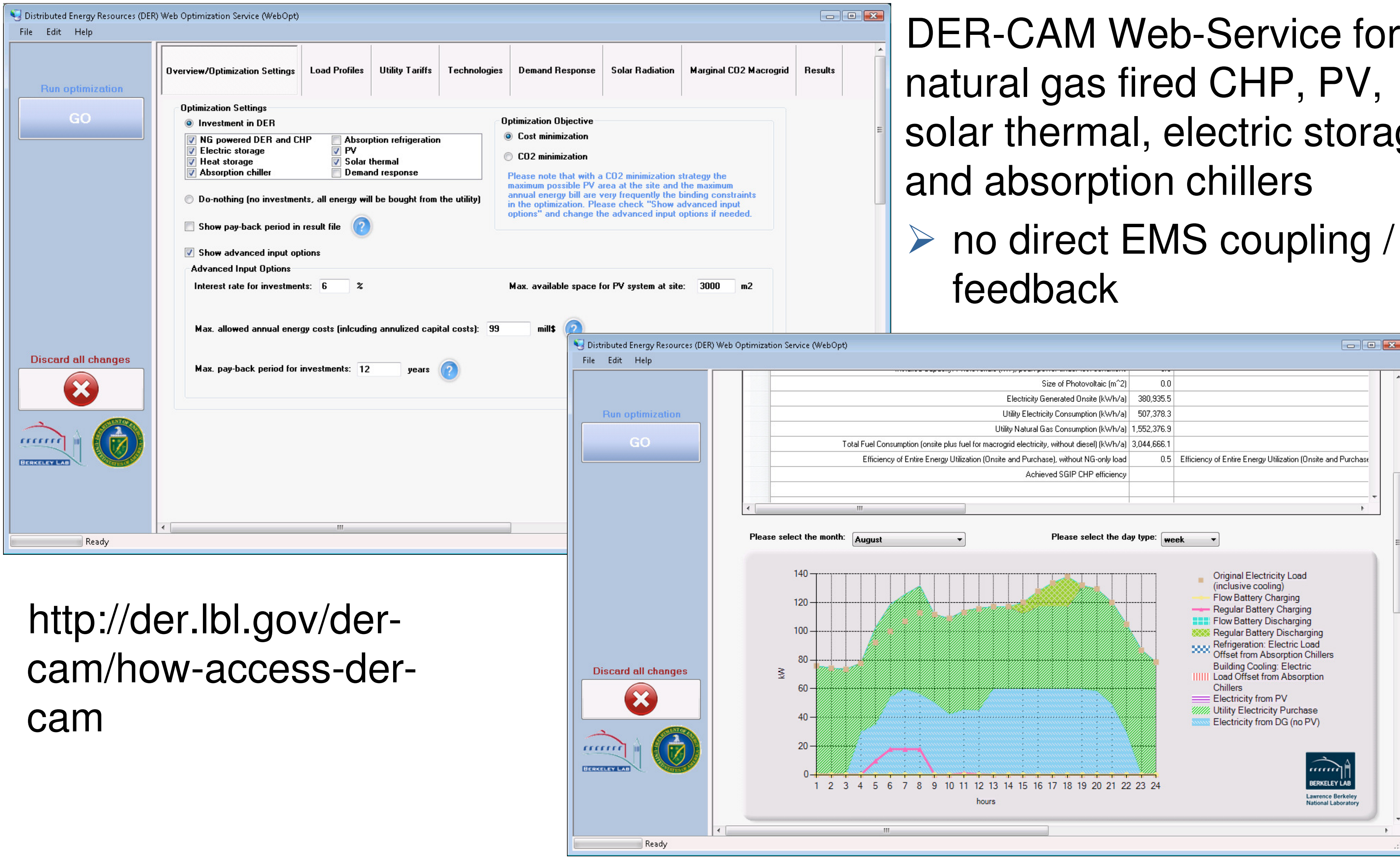
- **Investment & Planning:** determines optimal equipment combination and operation based on *historic* load data, weather, and tariffs
- **Operations:** determines optimal week-ahead scheduling for installed equipment and *forecasted* loads and weather, tariffs



Access to DER-CAM via WebOpt



Investment & Planning WebOpt: Web-Interface



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

- no direct EMS coupling / feedback

http://der.lbl.gov/der-cam/how-access-der-cam

Application 1: AEP

CERTS Microgrid *Concept*

– seamless islanding and reconnection via single PCC
– peer-to-peer, autonomous coordination among micro-sources (w/o high bandwidth communications)
– plug-and-play - no custom engineering
– energy manager on arbitrary platform

CERTS Microgrid *Test Bed Demonstration at AEP*

our objectives:

- generate load profiles and optimal scheduling for testing of 3 CHP systems
  - TECOGEN PROTOTYPE 60kW CHP
  - OLYMPIAN 100kW CHP
  - TECOGEN INV 100KW CHP
- develop automated interface for schedule delivery to AEP

Application 2: Santa Rita Jail (SRJ)

objectives:

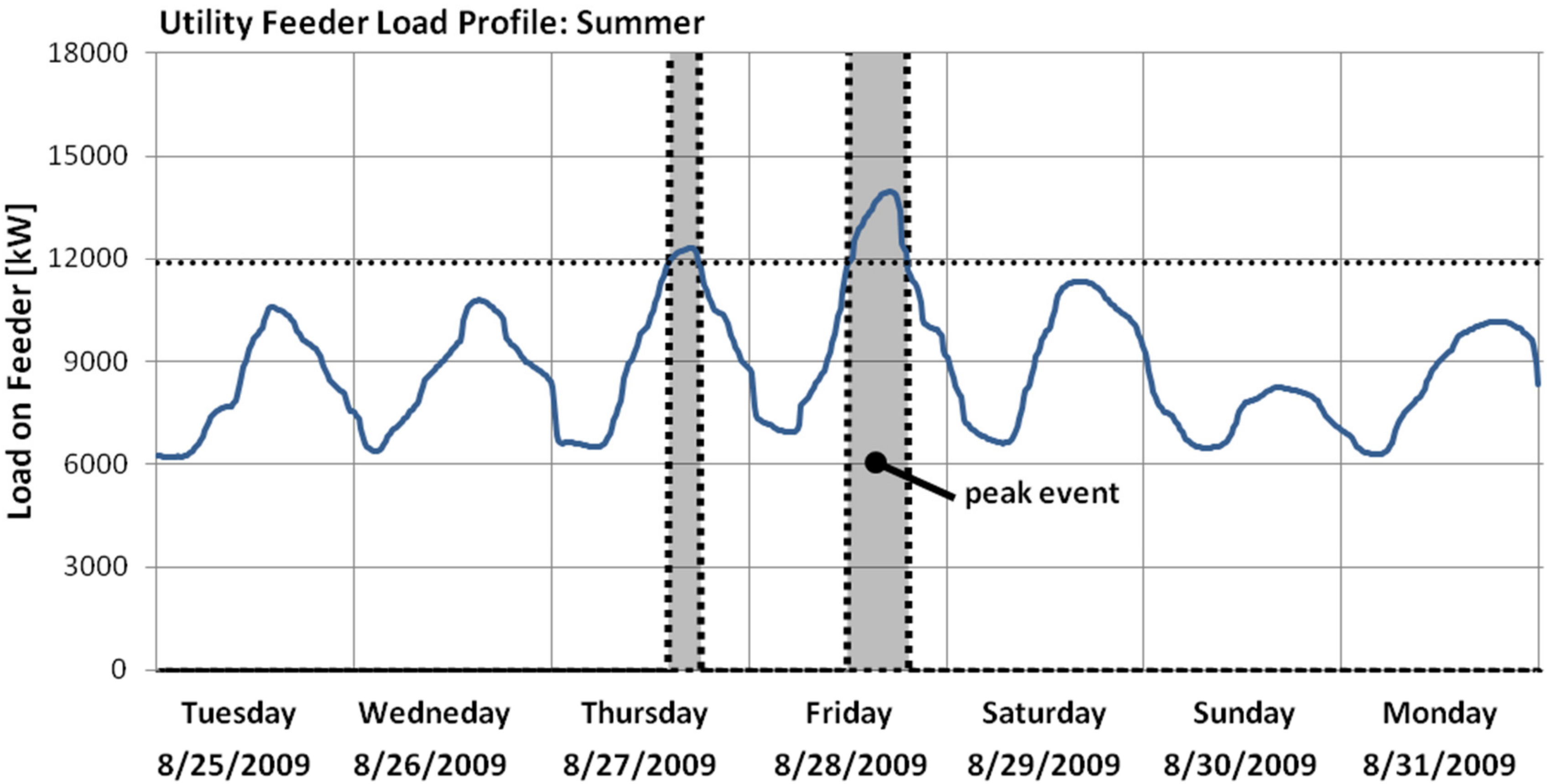
- deliver optimized week-ahead scheduling of onsite electric storage with Operations DER-CAM
- determine potential reduction in utility feeder peak demand through strategic battery dispatch

3 MW peak load facility
CERTS microgrid functionality

DER On-site:

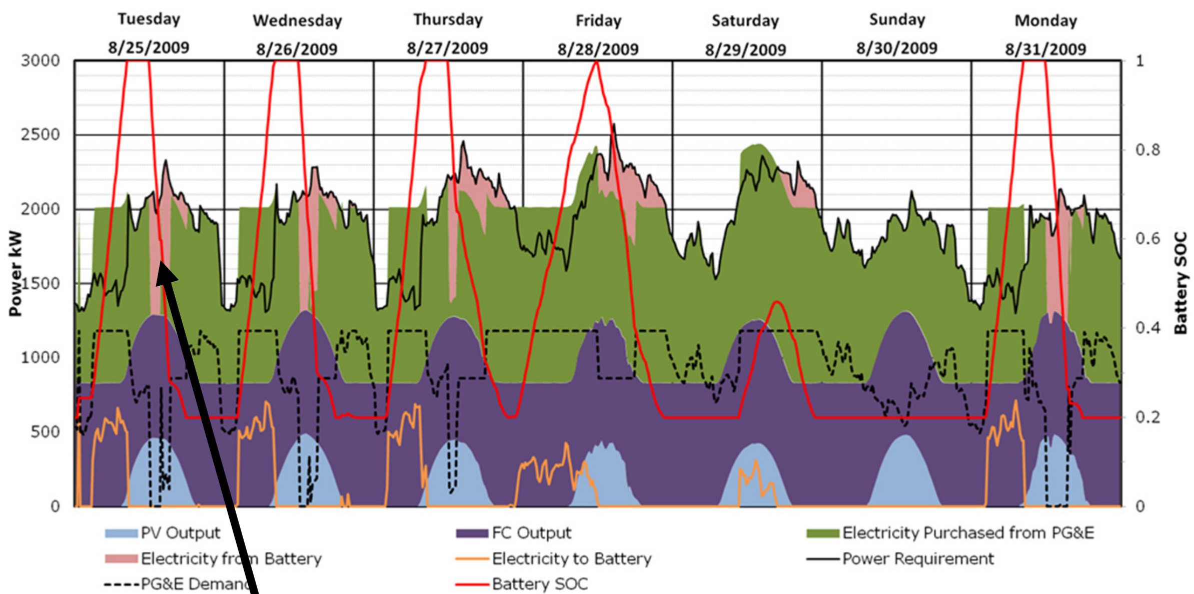
- photovoltaic: 1.2 MW peak
- fuel cell: 1 MW molten carbonate
- electric storage: 2 MW 2MWh Li-ion

SRJ: Utility Feeder Demand



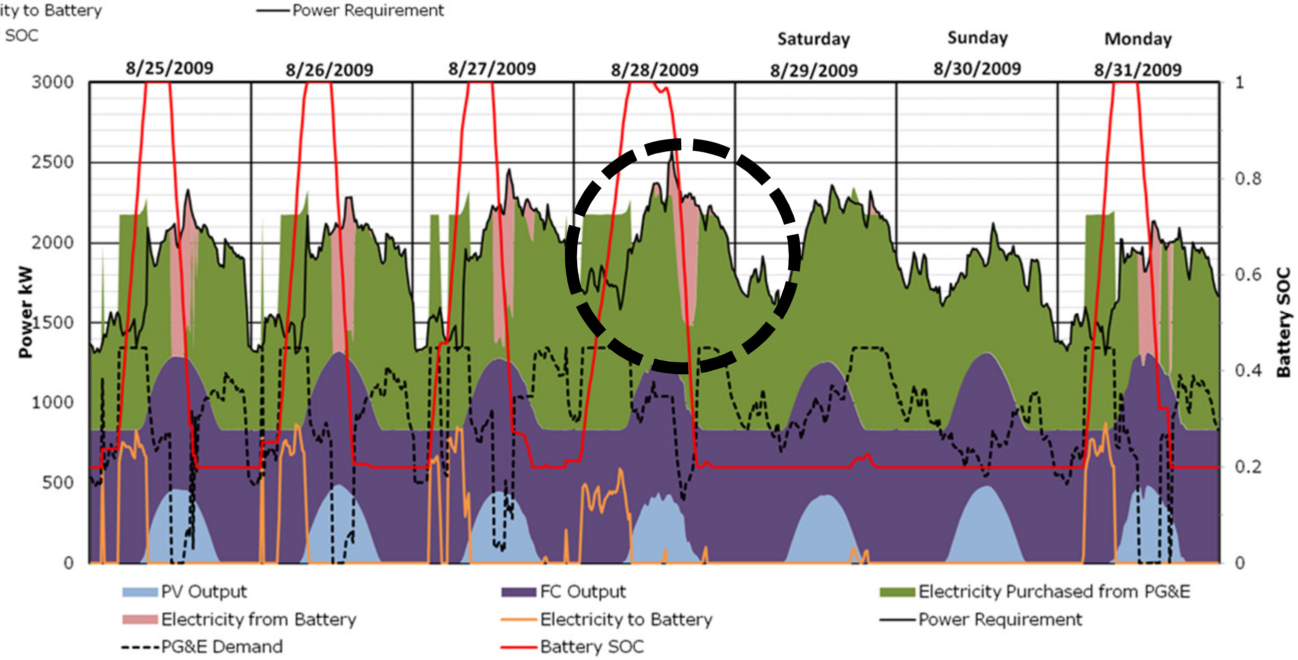
SRJ: Optimal Schedules*

Solution 1:
utility bill minimization



Solution 2:
feeder peak minimization
+$3.8k demand charge
3.5% reduction

DER-CAM minimizes on-peak purchases due to high demand charge



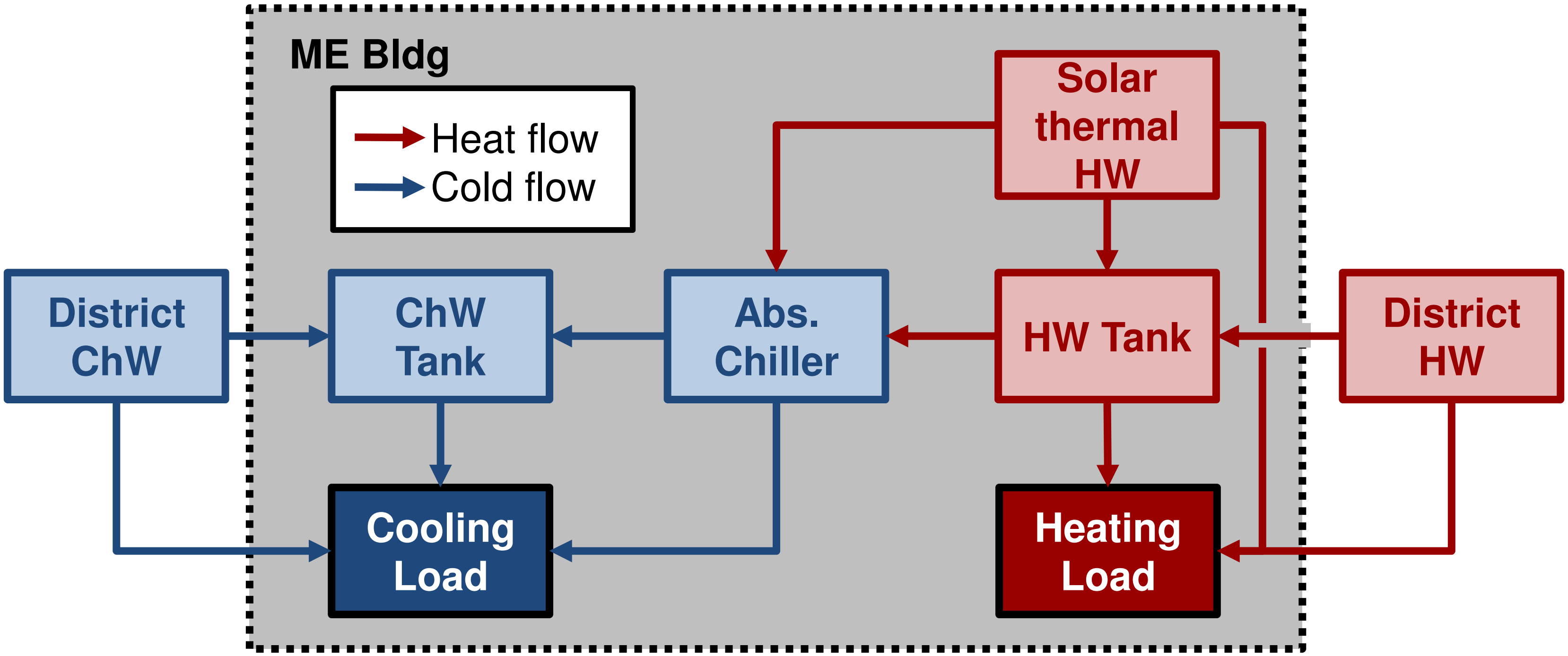
***Jail-Only Results**
(note scale)

Application 3: UNM

objectives:

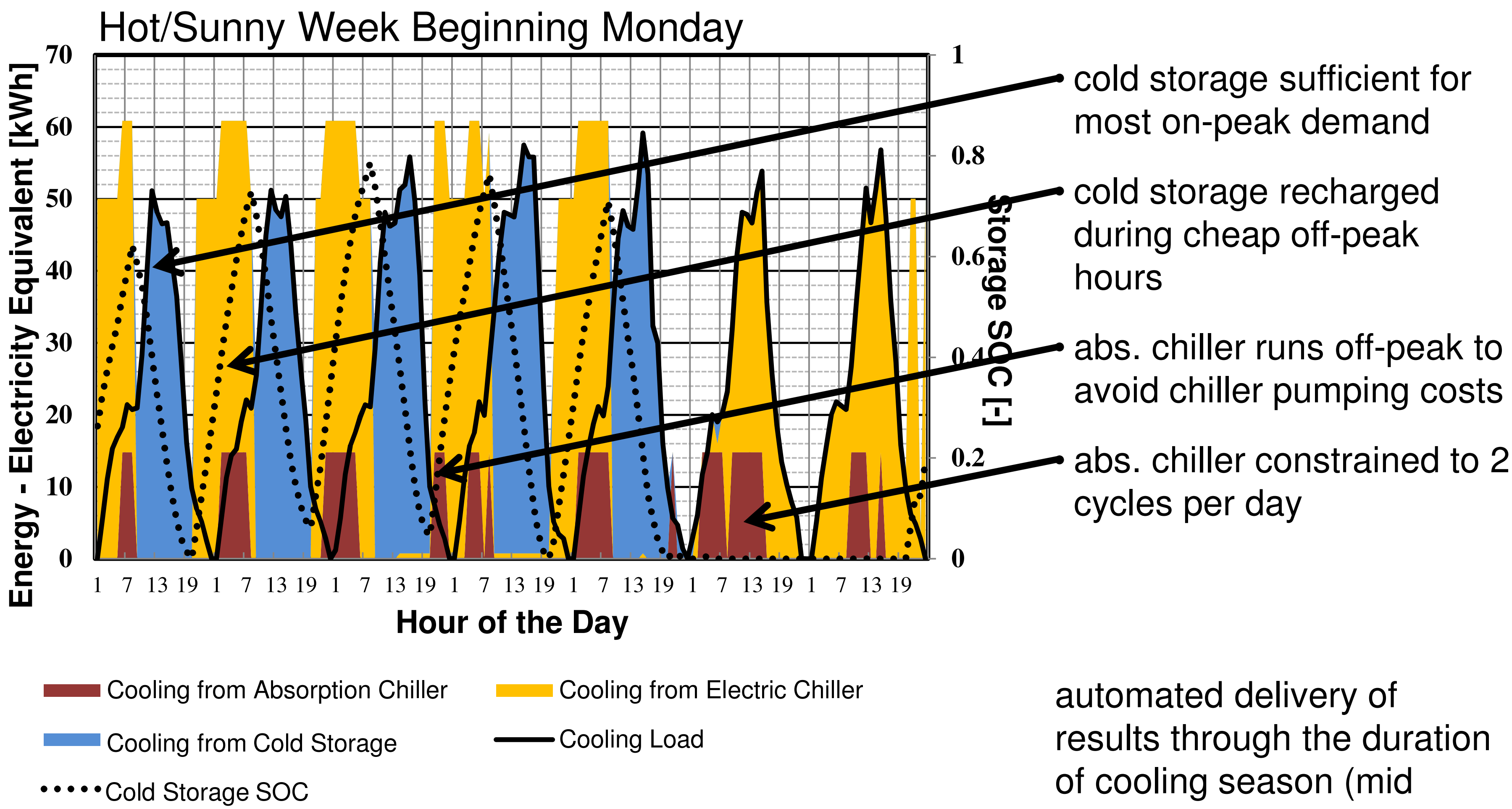
- generate optimized scheduling of cooling equipment
  - solar thermal collection
  - hot water storage
  - chilled water storage
  - absorption chiller
- deliver results daily via automated interface to UNM building control system (delta controller)

UNM Test Equipment/Configuration



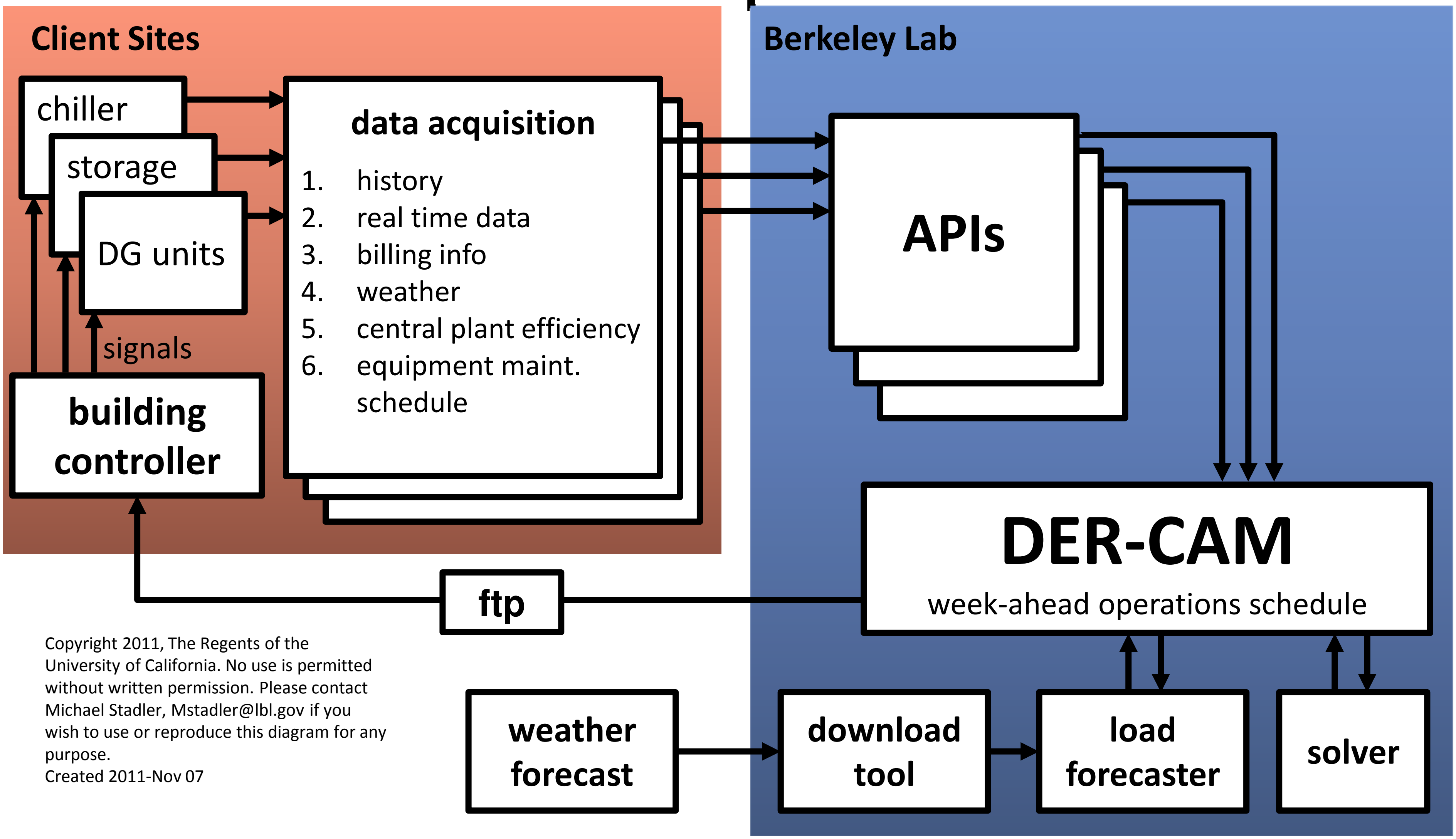
<u>equipment capacities:</u>
–solar thermal: 170 kW peak rating
–absorption chiller: 70 kW
–chilled water storage: 3800 kWh
–hot water storage: 300 kWh (9000 gallons)
(all values thermal)

UNM: Cooling Results



automated delivery of results through the duration of cooling season (mid October)

UNM WebOpt Structure



Created 2011-Nov 07

Further/Future Work

- sporadic fuel-cell outages complicate forecast of utility electricity demand → stochastic optimization
- microgrid multi-objective optimization framework
- plug-in electric vehicle demonstration at Los Angeles AFB
  role: extend demonstration to a true microgrid, provide OpenADR instructions from CAISO AS & SCE DR markets, optimize all bidding and scheduling (esp. PEV charging & discharging), control loads while grid connected, balance generation and prioritize loads while islanded
- finish Web-Interface for operations DER-CAM
- add new technologies, e.g. wind, heat pumps
- convert linear DER-CAM to a non-linear optimization to be able to capture technical constraints more realistically, e.g. efficiency curves
- integration of building energy simulation, flexible temperature set points, demand-side control
- power flow constraints, voltage support

End

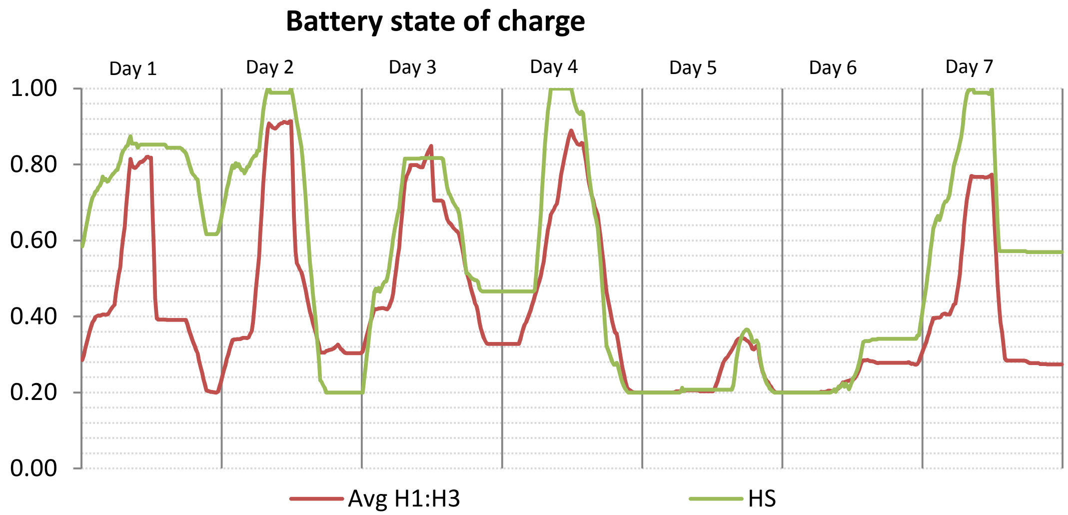
Thank you!

Questions and comments are very welcome.

Further Work/Uncertainty

- implementation of stochastic linear programming in Operations DER-CAM to model uncertainty
- possibility to explicitly account for uncertainty through user defined scenarios
- generic approach allows introducing uncertainty in multiple parameters, such as generation outages, fuel prices or weather conditions
- first application under design is the optimal battery scheduling at the SRJ under the uncertainty in fuel cell availability
- using the stochastic approach allows minimizing energy costs under any possible scenario realization

Further Work/Uncertainty, Draft Results



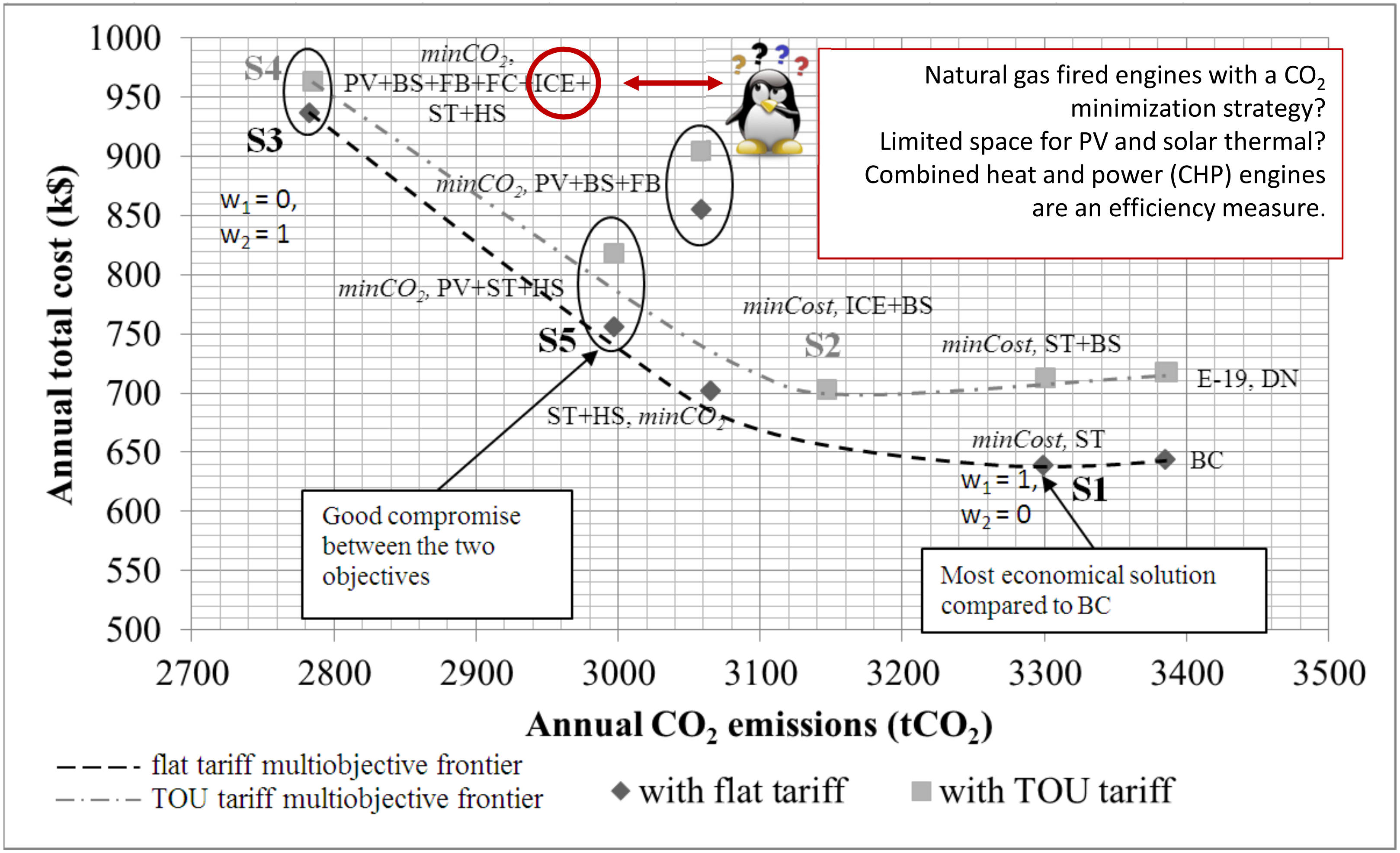
Avg. H1:H3 – Average of optimal battery schedules H1 to H3, obtained from fuel cell availability scenarios 1 to 3.

HS – Optimal battery schedule obtained by the stochastic model, where all scenarios are considered simultaneously.

Observed fuel cell scenario	1		2		3	
Battery schedule	Avg. H1:H3	HS	Avg. H1:H3	HS	Avg. H1:H3	HS
Total energy costs	$ 70 296	$ 69 126	$ 59 017	$ 57 560	$ 64 213	$ 60 431
TOU charges	$ 26 807	$ 26 837	$ 21 245	$ 21 351	$ 23 232	$ 21 821
Demand charges	$ 42 705	$ 41 567	$ 29 596	$ 28 160	$ 35 661	$ 30 968

- optimal battery schedules can be obtained assuming availability scenarios separately (deterministic approach) or simultaneously (stochastic approach)
- the stochastic approach yields lower energy costs in the realization of unexcepted events and a more conservative scheduling

Microgrid multi-objective optimization framework



PV: photovoltaic, BS: conventional lead acid battery, FB: Zinc Bromine flow battery, FC: fuel cell with waste heat utilization, ICE: internal combustion engine with waste heat utilization, ST: solar thermal conventional collectors, HS: Heat storage, BC: Base case, and DN: “Do nothing” case

More information at: der.lbl.gov