BUILDINGS ENERGY EFFICIENCY CONSORTIUM

U.S. - CHINA CLEAN ENERGY RESEARCH CENTER (CERC-BEE)

YEAR 4 JOINT ANNUAL MEETING

Berkeley California

Distributed Energy System and Renewable Energy Bldg. Integration (Projects D1+3 and E1)

U.S. and China Research Lead: Nan ZHOU (PI, LBNL), Michael STADLER (Co-PI, LBNL) , Neng ZHU (Tianjin Univ)

IAB Partners: Ed ABBO (C3 Energy)

US Partners: Brian ARELLANO (PNM), Johnson Controls Inc.

China Partners: Duo LUO (XingYe Solar), Enjun LI (Wuhan Rixin Technology)

UNM Partners: Andrea MAMMOLI (UNM)

H. Barsun, G. Cardoso, N. Deforest, Y. Ding, W. Feng, C. Gehbauer, L. Ghanbari, B. Jones, C. Marnay, **S. Mashayekh**, S. Pearsall, M. Robinson, M. Stadler, Z. Tian, and J. Zhao

Lawrence Berkeley National Laboratory

August 25, 2014

DER-CAM: http://building-microgrid.lbl.gov/

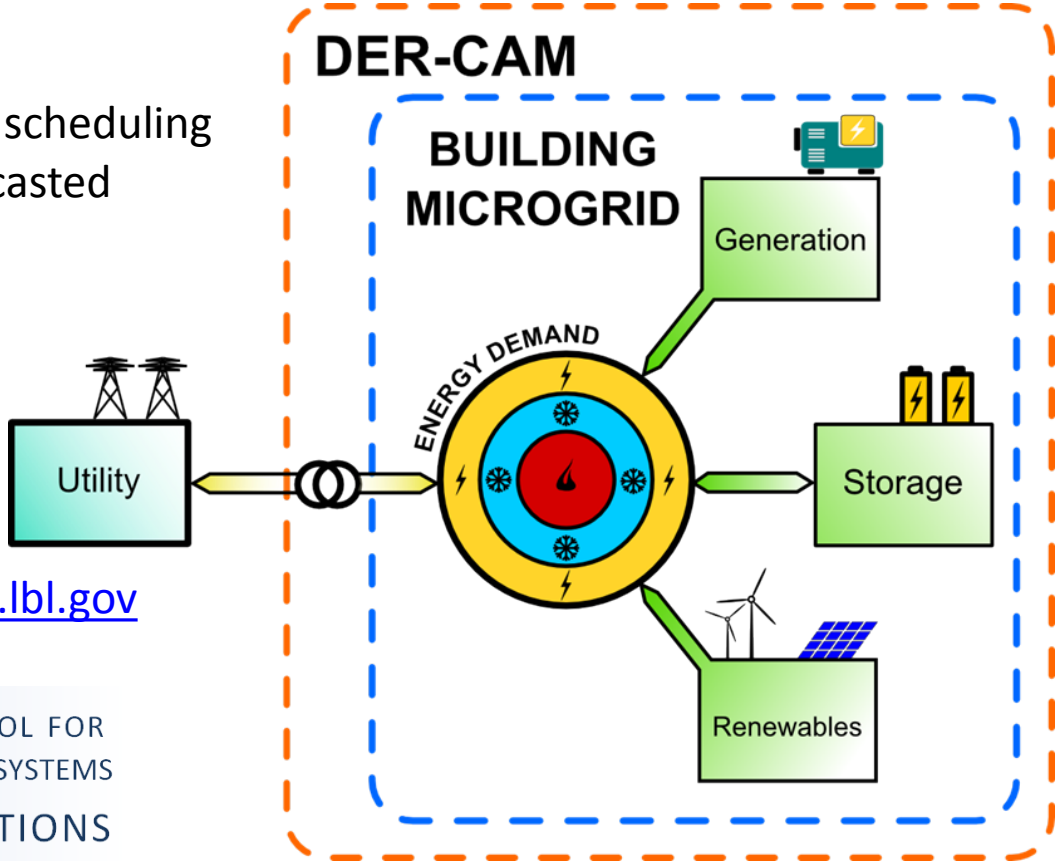
CERC: http://china.lbl.gov/

Introduction

- Research purpose: Use a Software as a Service (SaaS) model to provide optimal equipment selection and operation scheduling for low energy buildings
- Research objectives:
  - Develop Operations DER-CAM (ODC) models for 4 additional NM buildings and establish SaaS interfaces with their controls providers
  - Incorporate dynamic shading model into Operations DER-CAM
  - Provide equipment selection guidance for design phase of two MOHURD demonstration buildings, Zhuhai & Wuhan, and begin construction of ODC models
  - Pursue a US controls vendor for collaboration in Zhuhai
- Previous tasks:
  - Demonstrate remote control of loads in Tianjin University's Building 26
- Funding:
  - 107K$ carry-over, 26K$ remaining
  - 125K$ calendar year 2014 funds, 95K$ remaining

DER-CAM Introduction

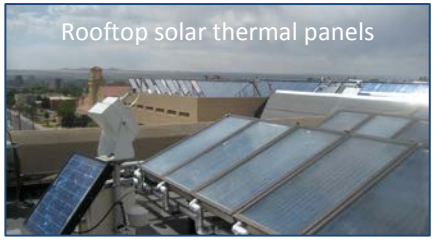
- DER-CAM, a decision support tool for decentralized energy systems:
  - Investment and Planning DER-CAM:
    Determines optimal equipment combination and operation based on historic load data, weather, and tariffs
  - Operations DER-CAM:
    Determines optimal week-ahead scheduling for installed equipment and forecasted loads, weather and tariffs
  - Run on LBNL servers in a Software-as-a-Service model
  - Contact: mstadler@lbl.gov
  - Online: http://building-microgrid.lbl.gov

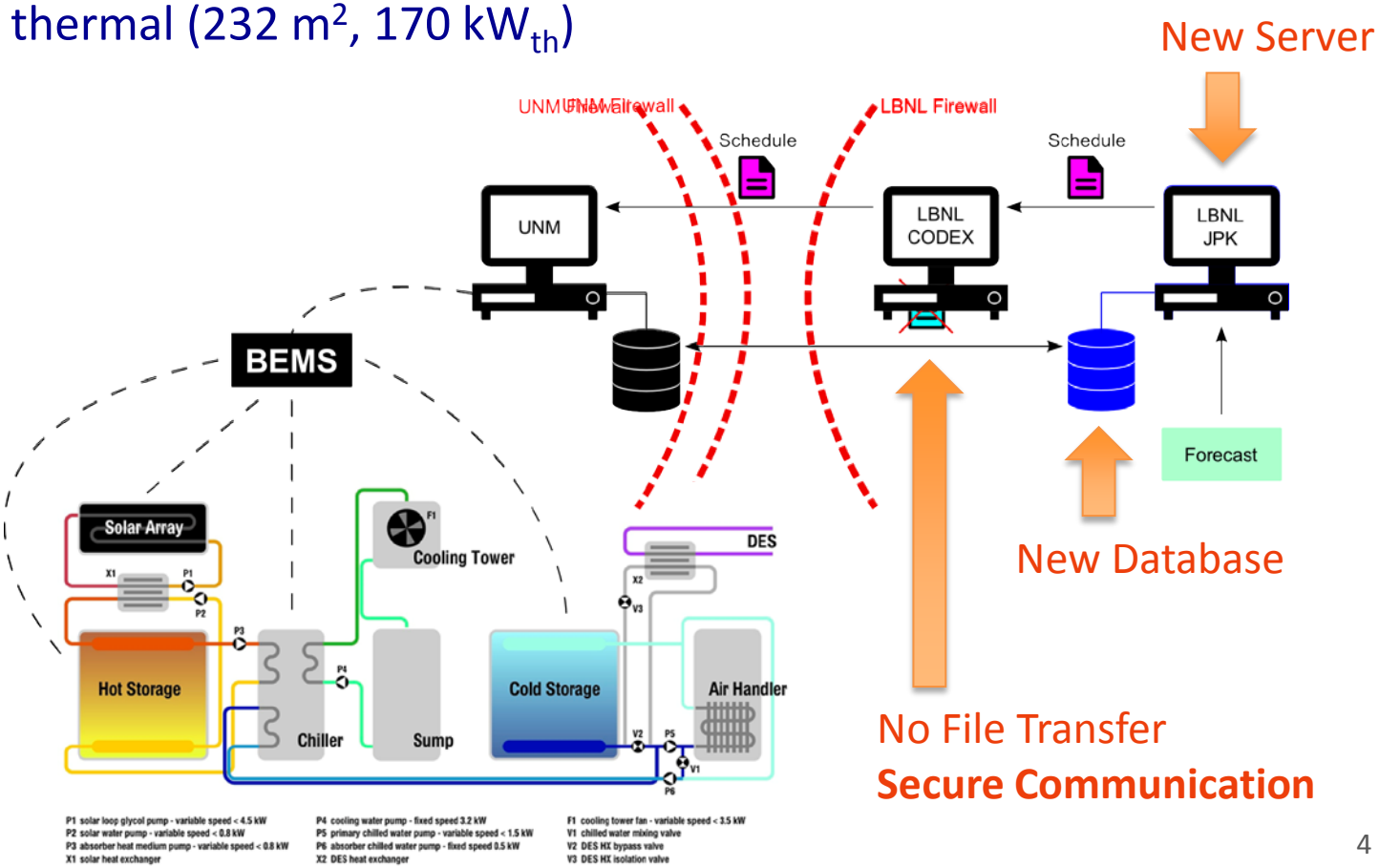


DER-CAM DECISION SUPPORT TOOL FOR DECENTRALIZED ENERGY SYSTEMS
ANALYTICS | PLANNING | OPERATIONS

NM Demonstration Bldg. – UNM ME

- Building: Mechanical engineering building, University of New Mexico
- Goal: Use the ODC as a SaaS for closed loop optimum cooling loop operation
- Technologies: heat storage (30 m^3, 510 kWh_{th}), cold storage (350 m^3, 2,620 kWh_{th}, about the cooling load in a summer day with 25 °C average), absorption chiller (70 kW_{th}), and solar thermal (232 m^2, 170 kW_{th})

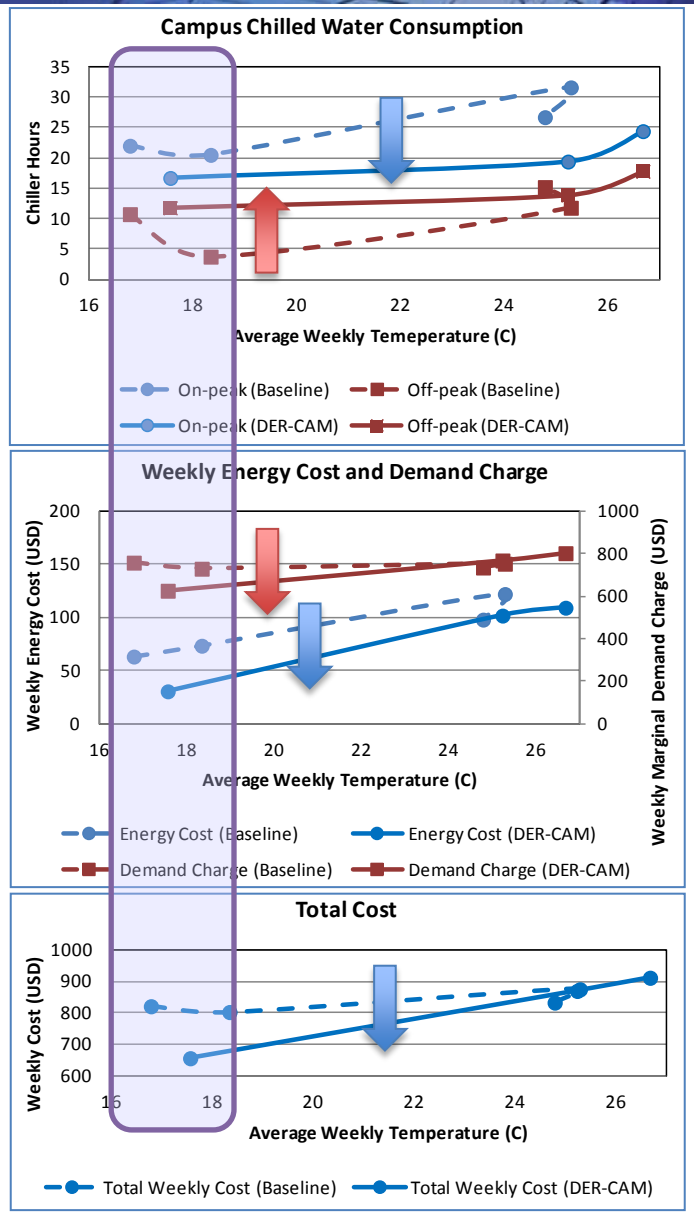




NM Demonstration Bldg. – UNM ME

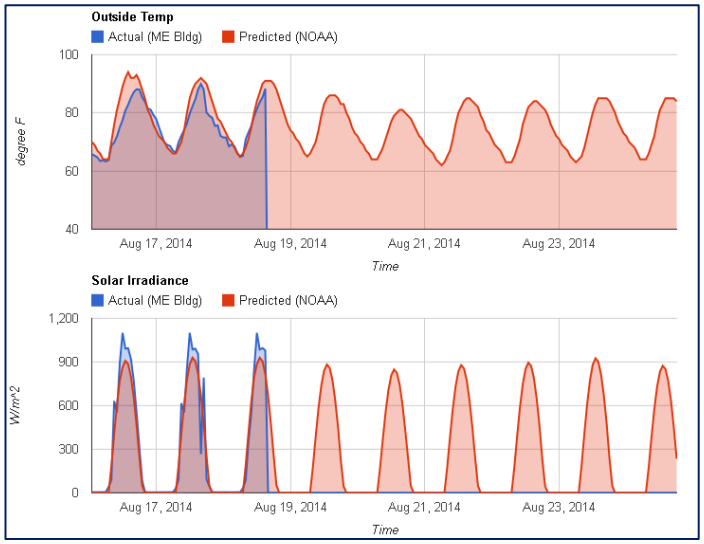
- Comparison of three DER-CAM operated and four baseline weeks in summer 2014:
  - Week of 05 May 2014 - Baseline – 16.8 °C
  - Week of 12 May 2014 - DER-CAM – 17.6 °C
  - Week of 20 May 2014 - Baseline – 18.3 °C
  - Week of 01 July 2014 - Baseline – 25.3 °C
  - Week of 08 July 2014 - DER-CAM – 25.2 °C
  - Week of 15 July 2014 - Baseline – 24.8 °C
  - Week of 22 July 2014 - DER-CAM – 26.7 °C

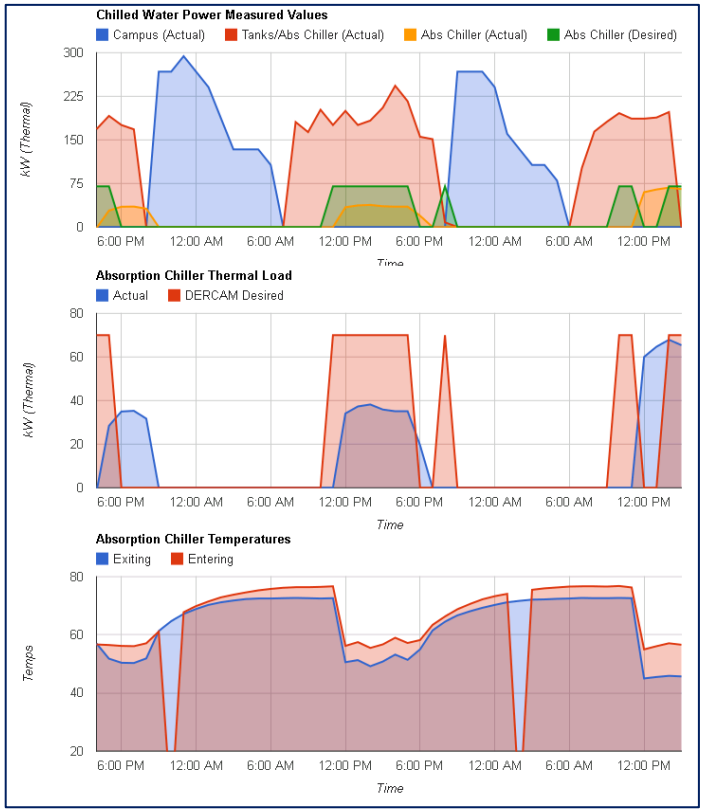
- Observations:
  - Better DER-CAM performance in cooler weeks
  - Comparison of the three weeks in May:
    - 55% saving in weekly energy cost
    - 16% saving in weekly marginal demand charge
    - 19% saving in total weekly cost

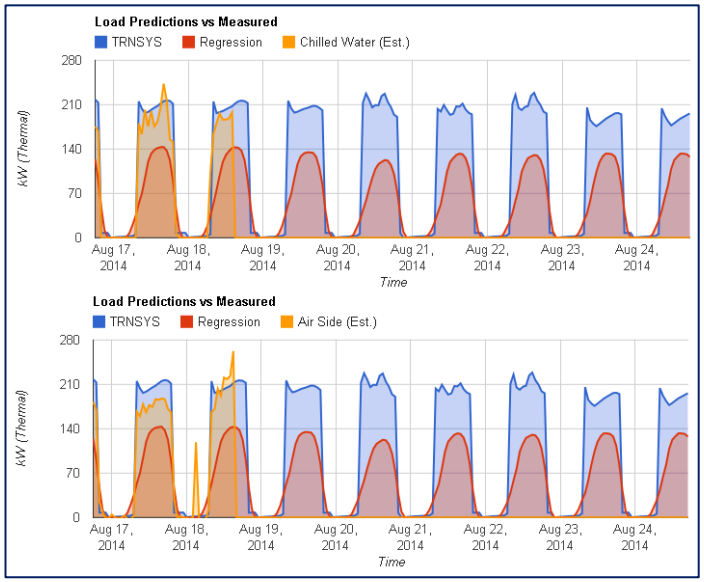


NM Demonstration Bldg. – UNM ME

- Online interface for the UNM ME building operation
- http://iseslab.unm.edu/dercam.html
- Measurements are shown in real-time
- DER-CAM schedules are depicted
- Deviations from the optimum schedules are visualized



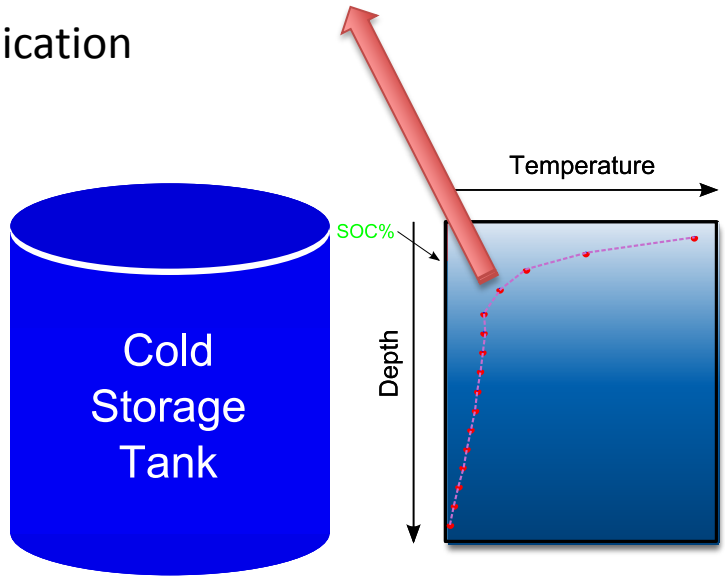




NM Demonstration Bldg. – UNM ME

- Progress made:
  - Closing the UNM – LBNL loop by receiving forecast/feedback from UNM
  - Developing the building model in TRNSYS and hence, improving the load forecasting
  - Developing an online interface

- Work in progress and challenges:
  - Integrating demand response into the Operations DER-CAM
  - Improving the reliability and security of communication
  - Improving the storage modeling in DER-CAM[1]
  - Dealing with implementation complications:
    - A unified approach to integrate DER-CAM with the building controls
    - Thermal stratification, and translating storage measured temperatures into a percentage State of Charge (SOC)



1. David Steen, Michael Stadler, Gonçalo Cardoso, Markus Groissböck, Nicholas DeForest, and Chris Marnay, "Modeling of thermal storage systems in MILP distributed energy resource models," Applied Energy, 2014, http://dx.doi.org/10.1016/j.apenergy.2014.07.036

NM Demonstration Bldg. – Hotel Andaluz

- Hotel Andaluz: Historic hotel located in downtown Albuquerque:
  - Floor space: 10,100 m^2
  - Resources: A 250 m^2 solar thermal array which heats a 15 m^3 hot water tank
  - Controls: Trane Tracer Summit
  - Annual consumption: ~1,450,000 kWh, ~240 kW peak, ~140,000 USD bill
  - Status and challenges:
    - Oversized solar-thermal system → Using I&P DER-CAM for resource utilization improvement
    - Thermal model of the hotel is almost ready
    - Some historic data available, but no automated data collection in place
    - A simple data collection needs to be installed to calibrate the model
    - After implementing I&P DER-CAM advice, the hotel may want optimized schedules, for which installing a reliable data collection is required

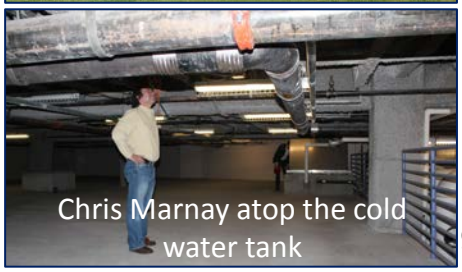
NM Demonstration Bldg. – One Sun Plaza

- One Sun Plaza: General office buildings in northern Albuquerque:
  - Floor space: Two buildings with 8,000 m^2 and 19,500 m^2
  - Occupants: 400 and 700
  - Notable tenants: U.S. Forest Service and Northrop Grumman
  - Resources: Central cooling plant beneath one bldg, 1,500 m^3 cold water tank (14,500 kWh_{th}), and two 1,690 kW Centravac Trane chillers
  - Annual consumption: ~8,200,000 kWh, ~1,400 kW peak, ~660,000 USD bill
  - Controls: Trane Tracer Summit
  - Status and challenges:
    - Initially there was no data collection (ODBC) → A basic data collection was installed
    - A TRNSYS model was developed and calibrated using GA with the historic data
    - Cyber-security is the major concern → the networks for the building controls and the tenants servers are being separated

One Sun Plaza

One of the two chillers

Thermocouple tree Access point to the in the tank


Chris Marnay atop the cold water tank

NM Demonstration Bldgs – Albuquerque Regency

- Albuquerque Regency: Two 22 story towers (one tower is general office space and the other one is a hotel, the Hyatt) in downtown Albuquerque:
  - Floor space: Total area of 111,500 m^2
  - Notable tenants: Much of the office space is occupied by GSA attorneys
  - Resources: Two 2,810 kW Trane Chillers that charge 44 Calmac IceBank tanks, giving a storage capacity of 128,000 kWh_{th} (65% of their total capacity)
  - Controls: Pneumatic and digital controls → The digital controls are Delta Controls
  - Status and challenges:
    - Some very general data collection has been done, but finer measurements are required
    - The thermal model in TRNSYS is almost complete and ready for calibration
    - Progress has been stalled due to facility manager's concerns about security, which are product of stringent contracts with GSA clients

IceBank storage units

Albuquerque Regency

Server room backup generator

Plate and frame heat exchanger

NM Demonstration Bldg. – Santa Fe Community College

- Santa Fe Community College – Trades and Advanced Technology Center: A section of the Santa Fe Community College located in southern Santa Fe:
  - Floor space: 3,700 m^2
  - Resources: Solar thermal array (90 panels, 73 kW_{th}), 140 kW adsorption chiller, 45 m^3 hot water tank, an evaporative cooler, a bio-gas boiler, and some PV (being installed)
  - Controls: METASYS Building Management System by Johnson Controls Inc.
  - Status and challenges:
    - The most interesting building among the four, due to 1) diverse resources, 2) academic and research environment, and 3) presence of JCI
    - Administration restructuring and a new facility manager, which has shows high interest
    - Data is being collected
    - A thermal model exists (must be calibrated)
    - LBNL /UNM are helping to resolve commissioning problems
    - The ODC will be integrated afterwards

SFCC Trades and Advanced Technology Center

Absorption chiller

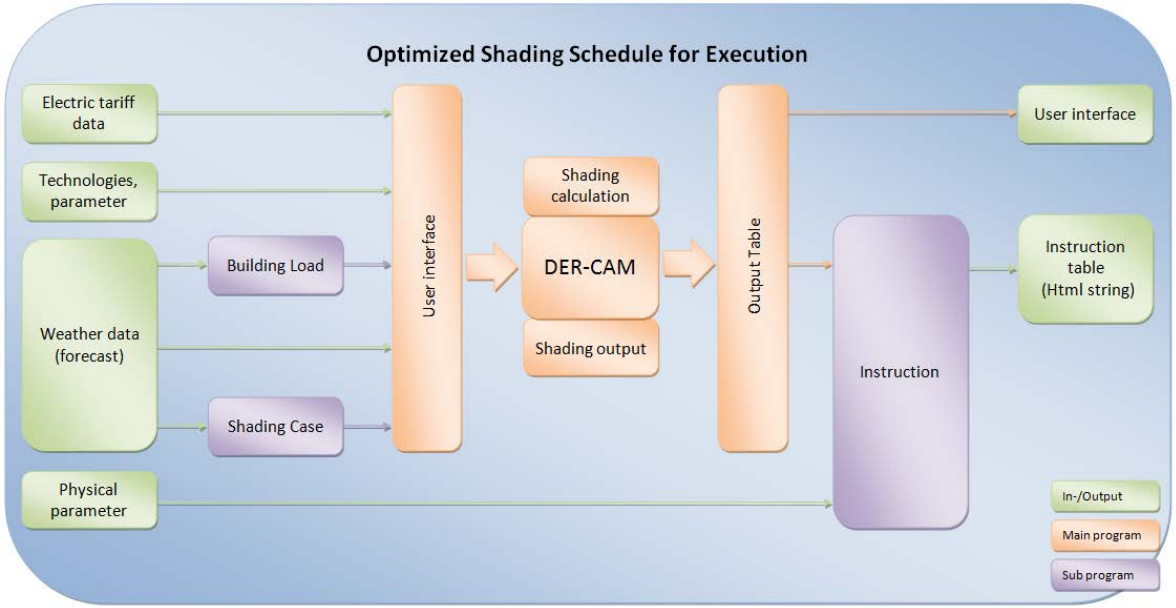
Evacuated tube solar thermal array

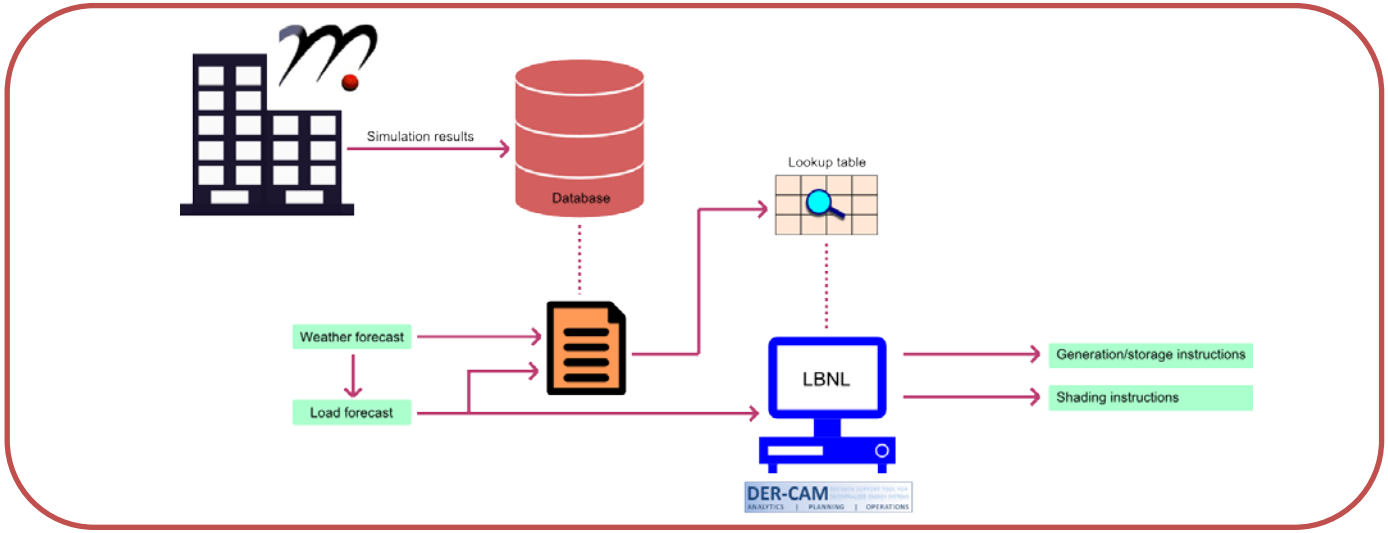
Hot water tank

Integrating Dynamic Shading Models into ODC

- ElectroChromic windows (EC) are a type of shading system. EC provide different levels of shading with a small electricity consumption required only for the switching process (0.5Wh/m^2, 5V)
- Trade-off: Increasing the shading level decreases the cooling loads, but increases the lighting load → An optimization is required
- An approach for variable shading support (EC windows, shutters, etc) in ODC was developed
- Integration of dynamic shading is interesting, since:
  - It affects other loads (end-uses)
  - Hence, makes the problem very complicated
    → DER-CAM can help
  - It is representative of demand-side technologies
    → Improvement in demand-side technologies in ODC

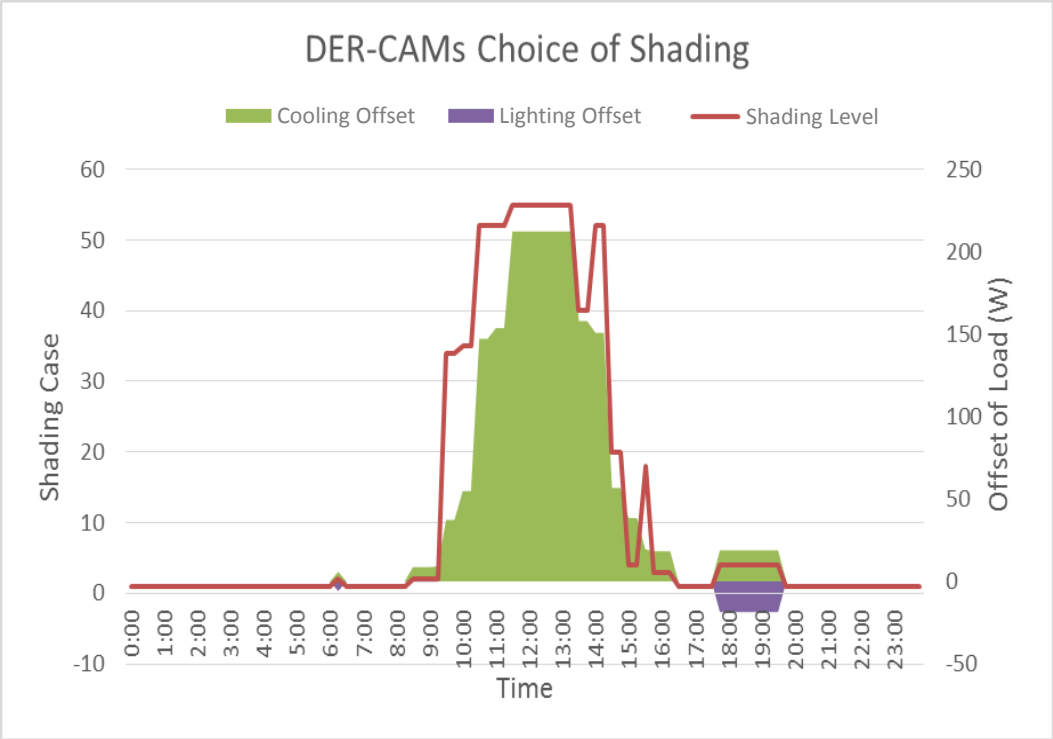
Integrating Dynamic Shading Models into ODC





Integrating Dynamic Shading Models into ODC

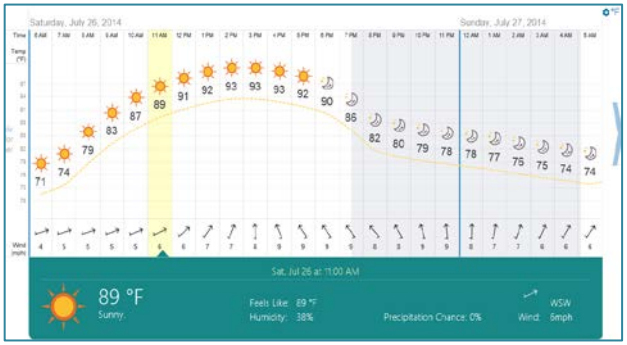
- An office building with PV and electrical storage[1]:
  - This figure shows one day (24 hours)
  - DER-CAM can choose between 64 different shading levels
  - Significant cooling load reduction and slight increase in lighting loads

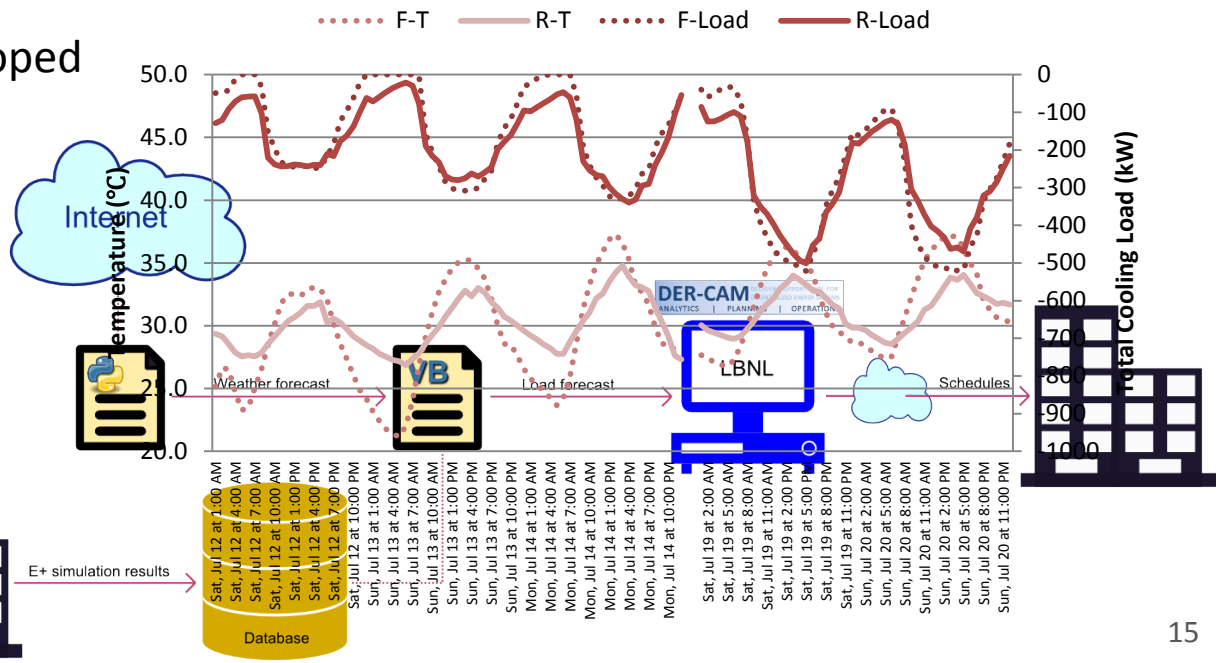


1. Christoph Gehbauer, "Implementation of shading technologies into linear optimization models," MSc Thesis, University of Applied Sciences Technikum Wien, Vienna, Austria, 2014.

Demonstration Bldg. - Tianjin Univ. Bldg. 26

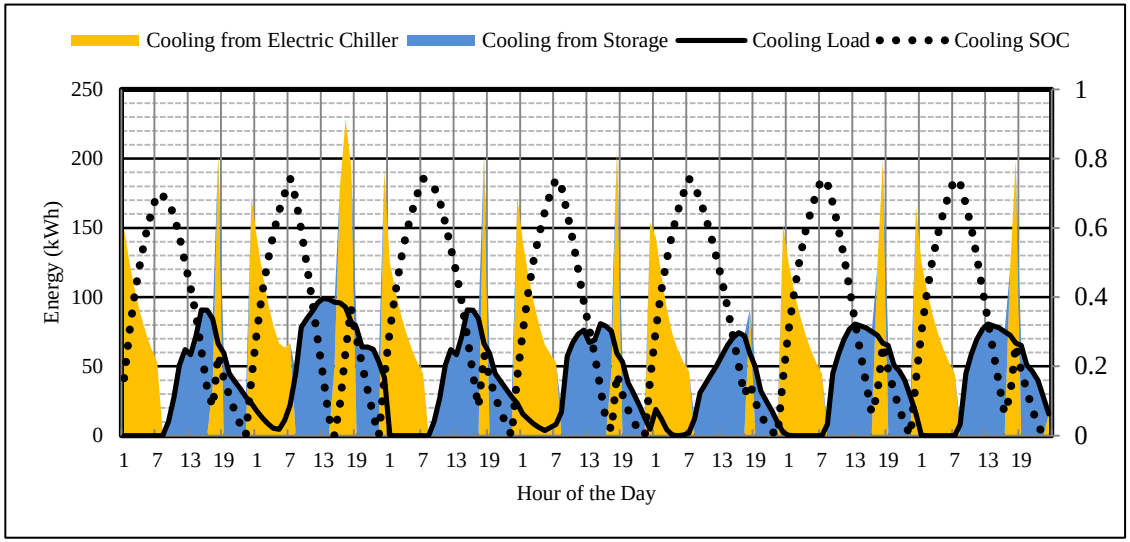
- A proof-of-concept for optimized building operation scheduling using Software as a Service (SaaS) in China
- Progress made so far:
  - An E+ model for the building was developed
  - A DB, composed of temperature and load data, was developed
  - Scripts developed to: a) obtain 7-day weather forecast, and b) find the closest match in the DB
  - An ODC model was developed

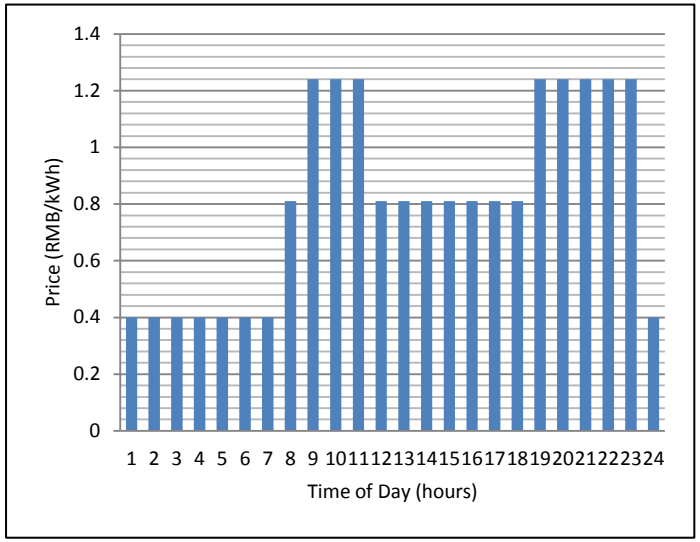




Demonstration Bldg. - Tianjin Univ. Bldg. 26

- Optimum cooling loop operation for building 26 for 17 July 14 – 23 July 14, assuming an arbitrary 7,500 kWh_{th} cold storage, with the following tariff





- Next steps:
  - Implementing the schedules using available controllable loads in the building, and potentially the wireless control system under development
  - Have it running by November for the Tianjin 2014 Symposium on Microgrids

A U.S. Controls Company for XingYe

- In the demonstration buildings in the U.S., we are:
  - Albuquerque Regency and UNM ME buildings have Delta Controls
  - One Sun Plaza building and Hotel Andaluz have Trane Controls
  - Santa Fe Community College has Johnson Controls

- Johnson Controls is the promising candidate, since:
  - They are interested in XingYE HQ, have agreed in principle to work with us, and have been directly talking to XingYe
  - They are present in Santa Fe Community College
  - They are also building a China headquarters in Shanghai

- We have also had discussions and may still work with:
  - Automated Logic Corporation
  - Siemens
  - Honeywell

XingYe Solar HQ and Wuhan Buildings

- XingYe Solar headquarter building:
  - We have had regular meetings with them:
    - Chris Marnay and Wei Feng attended meetings in China
    - We participated in several tele-conferences
  - Electrochromic windows technology has been integrated into the DER-CAM, with this project in mind
  - We have been actively looking to recruit an American controls vendor
  - Shi WANG will train BUCEA students on DER-CAM

- Wuhan buildings:
  - Tianjin University is active in this project
  - We are still waiting for the project to progress

Summary of the Next Steps

- New Mexico demonstration buildings:
  - Improving the closed-loop set-up in UNM ME by integrating demand response, using SQL data bases, stratification of the storage tank, and close tracking and comparison of predicted/scheduled/measured quantities
  - Alleviating cyber security concerns at One Sun Plaza and the Hyatt Regency, so our work can proceed
  - Resolving commissioning issues in the SFCC Trades and Advanced Technology Center, developing the Operations DER-CAM model, and integrating it with the controls
- Tianjin demonstration building 26:
  - Sending the schedules to some controllable loads in the building for proof of concept
- MOHURD demonstration buildings:
  - More discussions with US control vendors
  - Continue helping XY in the design phase and preparing the controls RFP
  - Developing the Operations DER-CAM models for the buildings when the design phase has progressed enough

THANK YOU!
Q&A