Distributed Energy Site Simulation (DESS)

Distributed Energy Enabling Technologies: Site Energy Simulation (B&R EO-0102010)
Area 2: Sensors and Controls

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by

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Outline

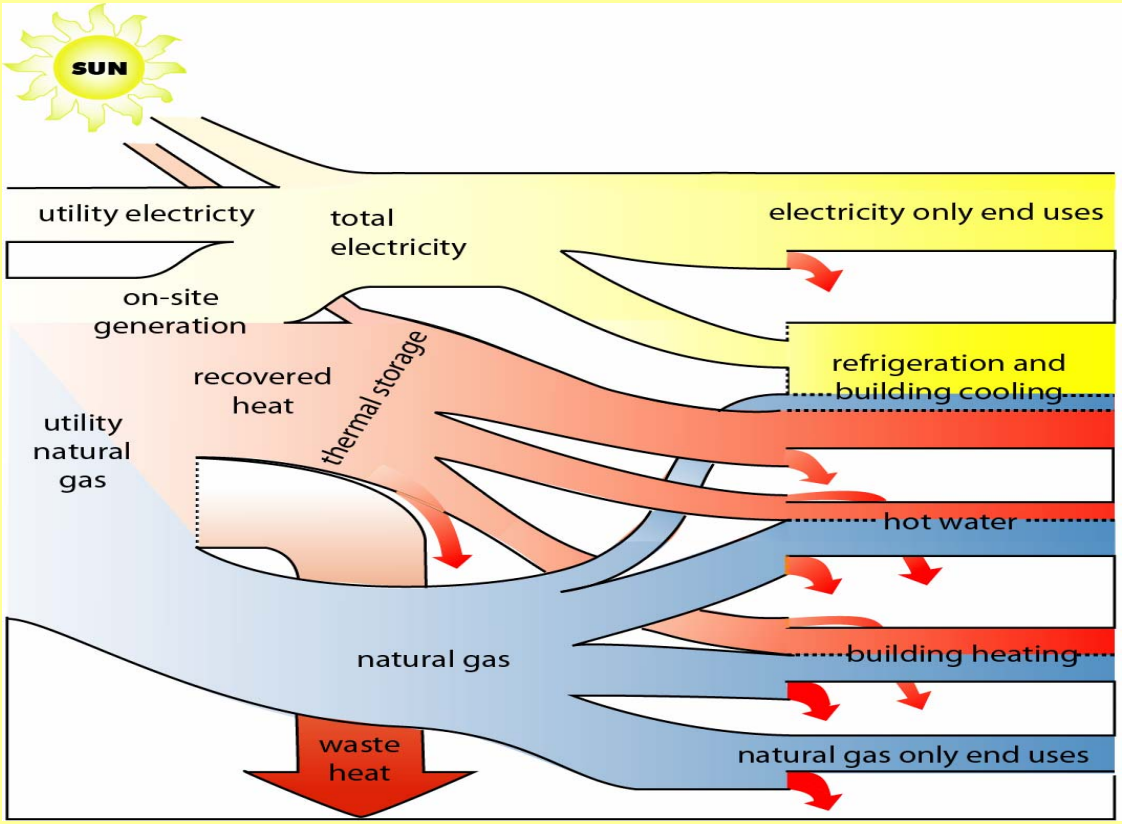
Project Goal: accelerate building integrated DG adoption by

- developing near-optimal control algorithms for operation and simulation of DG systems using expertise from previous work
- implement control algorithms in a platform neutral EnergyManager and make it, together with other DG-CHP capabilities available in a widely-used simulation tool (EnergyPlus)
- validate results through example building simulations

1. Distributed Energy Resources Customer Adoption Model (DER-CAM)
2. EnergyPlus/SPARK simulation tool
3. DESS project outline
4. Potential collaboration with PNNL

DER-CAM Concept

energy flows in building from fuels to end uses

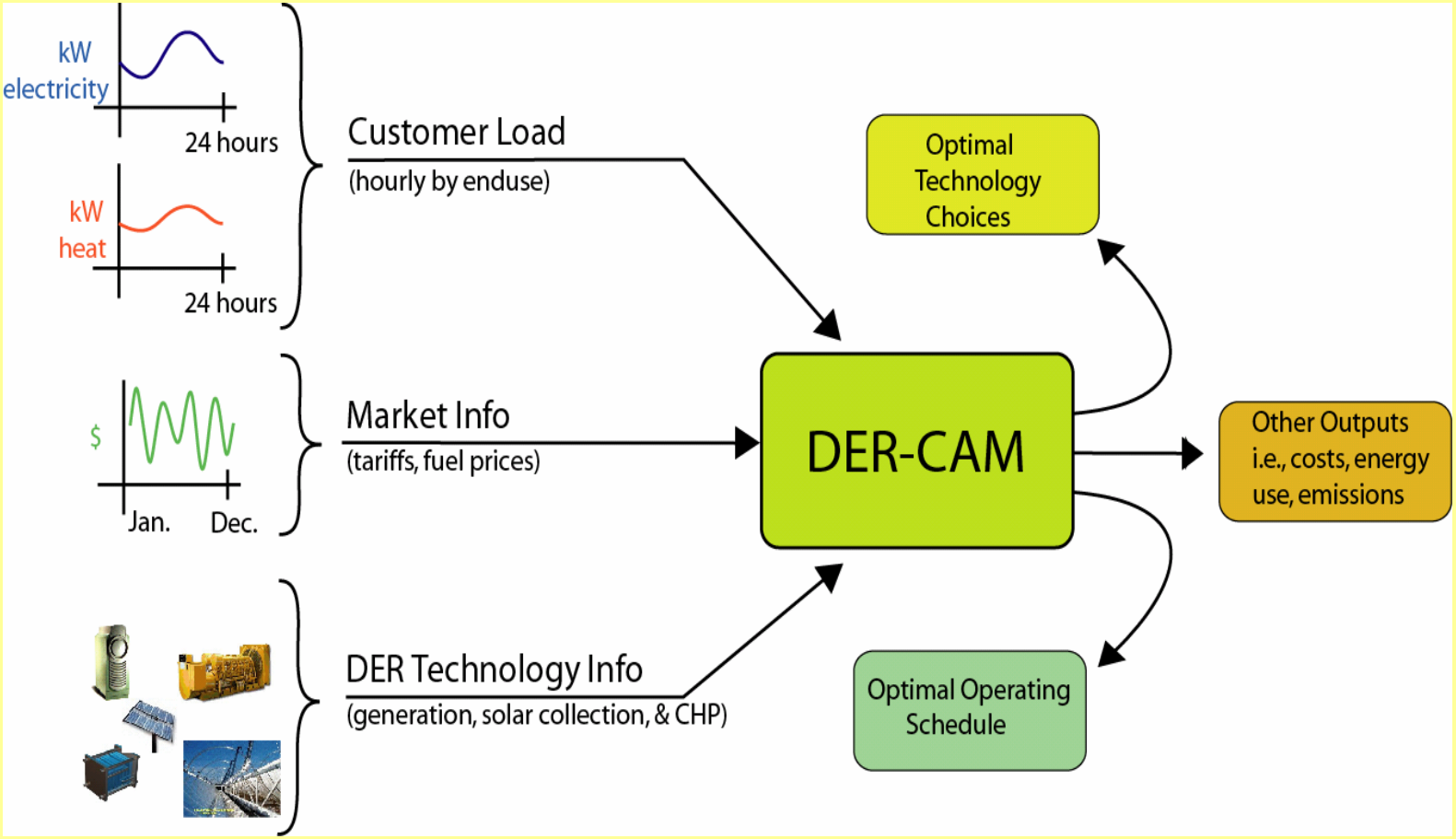


DER-CAM is an optimization model that identifies optimal DER investment choice and operation for a site, given:

- energy load profiles
- tariff details
- DER equipment options

holistic, integrated, enduse focused analysis of entire building energy system

DER-CAM Data Flow



DER-CAM Mathematical Model

- DER-CAM uses GAMS to model an MIP solved with Cplex
- minimize
  - customer (annual) energy bill

    (DER investment, DER operation, energy purchases, energy sales) annualized
- subject to:
  - energy balance
  - electricity & NG tariffs
  - DER characteristics (investment cost, heat rate, and maintenance cost)
  - heat production/available waste heat/CHP technology
  - solar insulation/environmental permit conditions/etc.

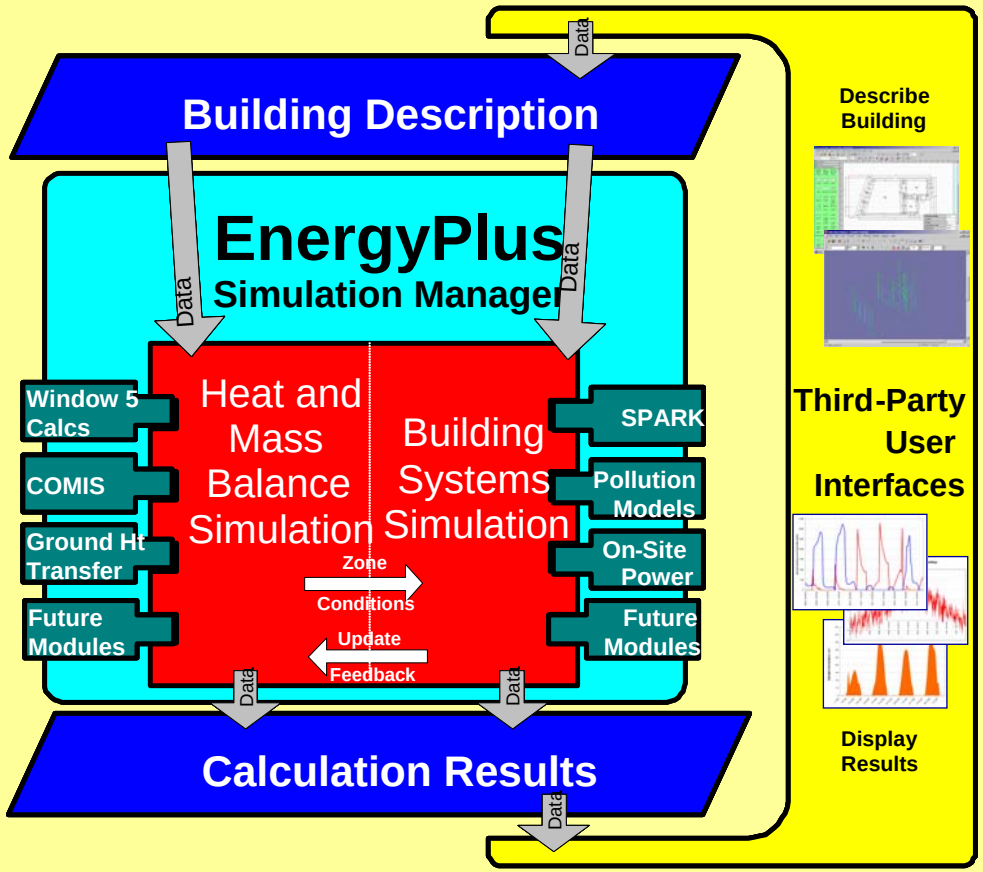
EnergyPlus Background

http://www.energyplus.gov

Building energy simulation program for modeling building heating, cooling, lighting, ventilating, and other energy flows.

- All-new fully integrated building & HVAC simulation program
  - Funded by DOE, BT Office (Program Manager: Dru Crawley)
  - Will replace BLAST, DOE-2 tools
  - Version 1.2.3 (October 2005), ~30,000 downloads
- Simulation engine only
  - Heat balance based solution technique for building thermal loads
  - Flexible specification of HVAC equipment topology
  - No real DG capability at this point!

EnergyPlus (2/2)



Simultaneous simulation of loads, systems & plant

- Air and water loops solved iteratively at each time step
- Integrated simulation allows capacity limits to be modeled more realistically
- So far only idealized, high-level supervisory controls
- More detailed analysis of building components done in SPARK

Typical outputs

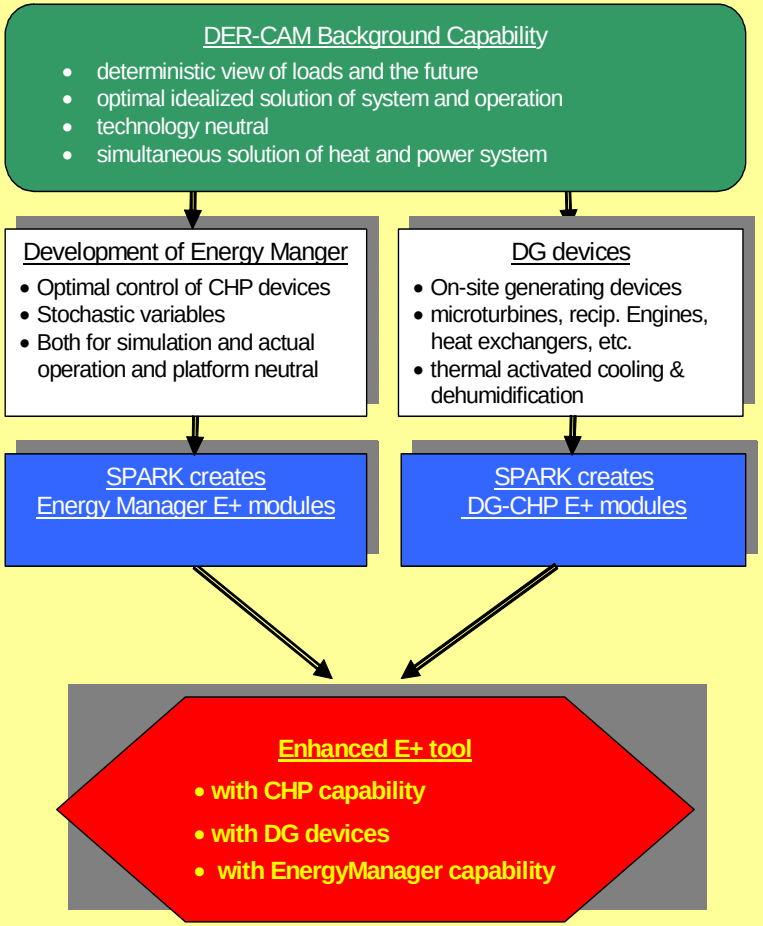
- Heating and cooling loads (daily, weekly, yearly)
- Energy consumption, emissions, comfort
- Equipment performance

SPARK / E+

- SPARK is a generic, equation-based DAE solver
  - Used to generate robust, fast solvers for mathematical description of physical models
  - Automatically derives solution sequence optimized for computational speed
- SPARK link to E+ is a non-intrusive mechanism to add new component models to E+
  - Performs data mapping between E+ and SPARK variables
  - E+ drives SPARK models (steady-state or dynamic)
  - SPARK models possibly solved at smaller time step than E+ HVAC time step

Project Outline

- Energy Manager algorithm development (FY05,06)
- DG enhancements to E+ (FY06,07)
- Incorporation of Energy Manager in E+ (FY07)
- Modeling and simulation of test sites (FY07)

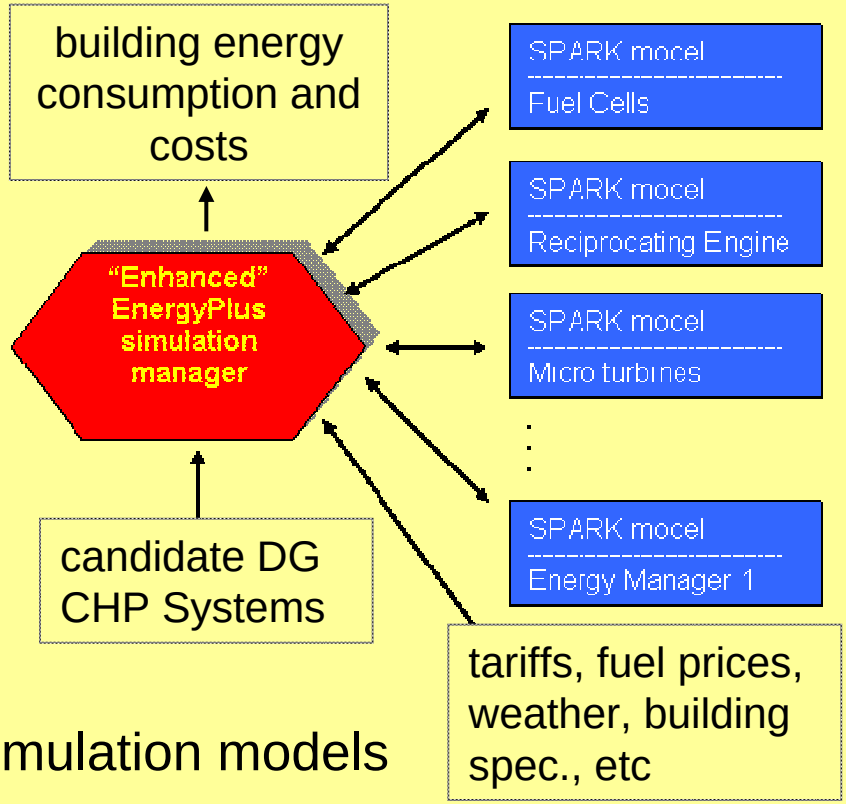


From DER-CAM to the Energy Manager in E+

- DER-CAM
  - Determine optimal investment decision based on deterministic view of future
  - Chooses DER systems and estimates performance under economic optimization
- Energy Manager in E+
  - Continuously determine near-optimal dispatch of an installed system in response to:
    - Non-deterministic view of the future (~real-time)
    - Current conditions (tariffs, outages, end-use load changes, demand-response requests, ...)
  - More realistic assessment of DER system and on-site controls due to integrated, simultaneous calculation

Conclusion

- DESS is aimed directly at a specific market barrier
- namely, limitations on building energy simulation of CHP systems
- EnergyPlus (E+) a replacement for the widely used DOE-2
- enhance E+ by adding modules to:
  - to simulate DG-CHP devices
  - to simulate effects of controls
- project marries two capabilities developed at Berkeley Lab
  - E+ generation of building energy simulation models
  - Distributed Energy Resources – Customer Adoption Model
- result should be an effective tool for energy simulation of CHP equipped buildings



Project Team

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