DER-CAM - Distributed Energy Resources Customer Adoption Model

DER-CAM's objective is to minimize annual energy costs for a modeled site, including utility electricity and natural gas costs, amortized capital costs for distributed generation (DG) investments, and maintenance costs for installed DG equipment.

Following technologies are currently considered:

- Natural gas-fired reciprocating engines, gas turbines, microturbines, and fuel cells;
- Photovoltaics and solar thermal collectors;
- Heat exchangers for application of solar thermal and recovered heat to end-use loads; and
- Heat-driven absorption chillers.

DER-CAM has been developed as a flexible tool capable of modeling a wide variety of commercial and small industrial sites.

Key site-specific inputs to the model include end-use energy loads, electricity and natural gas tariffs, and DG equipment characteristics.

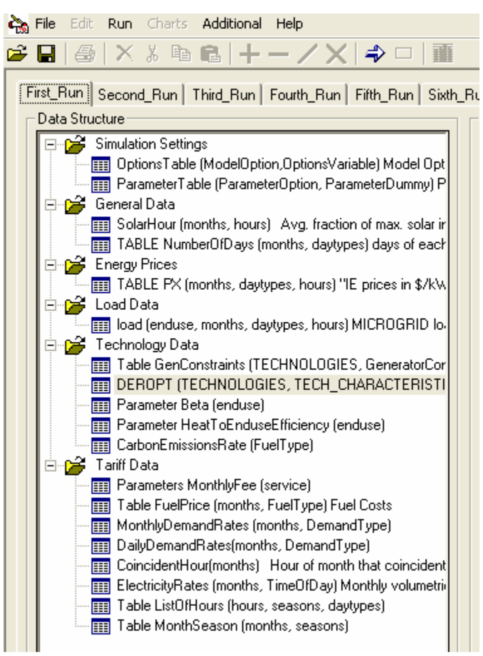


Fig. 1 User Friendly Input Interface (UFII)

DER-CAM is a Mixed Integer Linear Optimization Program (MILP) written and executed in the General Algebraic Modeling System (GAMS, www.gams.com).

An Input – Output interface for commercial usage exists to ease the data manipulation and creation of sensitivity analyses. No GAMS coding by the user is required (see picture above, User Friendly Input Interface, UFII).

DER-CAM is technology neutral and can consider almost any desired DG/CHP (CHP: combined heat and power) system.

Simultaneous Optimization Approach of DER-CAM:

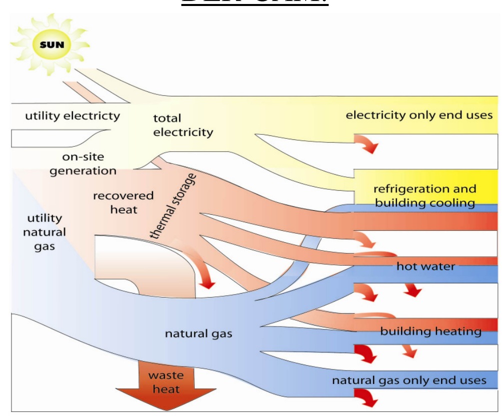


Fig. 2 Energy Flows From Fuels to End Uses in DER-CAM

Figure 2 shows a high-level schematic of the energy flow modeled in DER-CAM. Possible energy inputs to the site might include solar insolation and utility electricity and natural gas. For a given DG investment decision, DER-CAM selects the optimal combination of utility purchase and on-site generation required to meet the site's end-use loads at each time step as summarized below:

- Electricity-only loads (e.g. lighting and office equipment) that can only be met by electricity
- Cooling loads that can be met either by electricity or by heat (using an absorption cycle)
- Hot water and space heating loads that can be met either by recovered heat or by natural gas

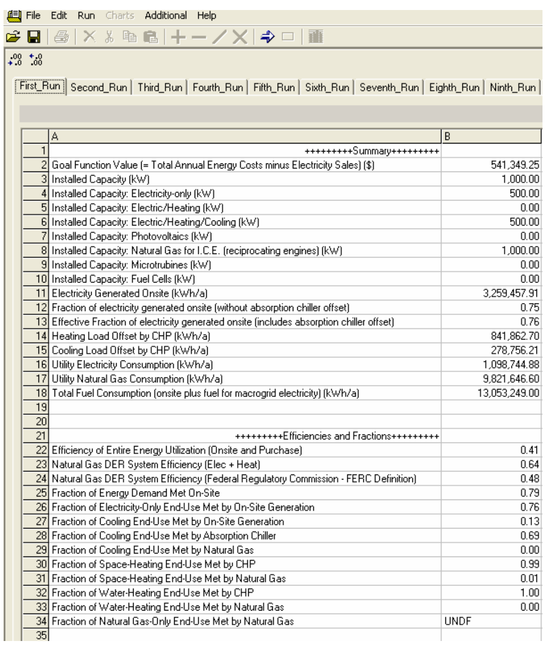
- Natural gas-only loads (i.e. mostly cooking) can only be met by natural gas.

A key constraint is a limit on the acceptable simple payback period, which mimics perceived real-world investment decisions; that is, only investment options with a payback period less than that specified as an input model parameter are considered.

Key outputs of DER-CAM include

- optimal DG/CHP investment choice
- operating schedule of DG equipment
- energy purchases
- energy costs
- efficiencies
- fuel consumption and emissions

All outputs are reported in both summary and detailed formats.



	A	B
1	+++++++++Summary+++++++++	
2	Goal Function Value (= Total Annual Energy Costs minus Electricity Sales) ($)	541,349.25
3	Installed Capacity (kW)	1,000.00
4	Installed Capacity: Electricity-only (kW)	500.00
5	Installed Capacity: Electric/Heating (kW)	0.00
6	Installed Capacity: Electric/Heating/Cooling (kW)	500.00
7	Installed Capacity: Photovoltaics (kW)	0.00
8	Installed Capacity: Natural Gas for I.C.E. (reciprocating engines) (kW)	1,000.00
9	Installed Capacity: Microtrubines (kW)	0.00
10	Installed Capacity: Fuel Cells (kW)	0.00
11	Electricity Generated Onsite (kWh/a)	3,259,457.91
12	Fraction of electricity generated onsite (without absorption chiller offset)	0.75
13	Effective Fraction of electricity generated onsite (includes absorption chiller offset)	0.76
14	Heating Load Offset by CHP (kWh/a)	841,862.70
15	Cooling Load Offset by CHP (kWh/a)	278,756.21
16	Utility Electricity Consumption (kWh/a)	1,098,744.88
17	Utility Natural Gas Consumption (kWh/a)	9,821,646.60
18	Total Fuel Consumption (onsite plus fuel for macrogrid electricity) (kWh/a)	13,053,249.00
19		
20		
21	+++++++++Efficiencies and Fractions+++++++++	
22	Efficiency of Entire Energy Utilization (Onsite and Purchase)	0.41
23	Natural Gas DER System Efficiency (Elec + Heat)	0.64
24	Natural Gas DER System Efficiency (Federal Regulatory Commission - FERC Definition)	0.48
25	Fraction of Energy Demand Met On-Site	0.79
26	Fraction of Electricity-Only End-Use Met by On-Site Generation	0.76
27	Fraction of Cooling End-Use Met by On-Site Generation	0.13
28	Fraction of Cooling End-Use Met by Absorption Chiller	0.69
29	Fraction of Cooling End-Use Met by Natural Gas	0.00
30	Fraction of Space-Heating End-Use Met by CHP	0.99
31	Fraction of Space-Heating End-Use Met by Natural Gas	0.01
32	Fraction of Water-Heating End-Use Met by CHP	1.00
33	Fraction of Water-Heating End-Use Met by Natural Gas	0.00
34	Fraction of Natural Gas-Only End-Use Met by Natural Gas	UNDF
35		

Fig.3 Summary Results for a Typical San Francisco Office Building

Fig 4 shows the DER-CAM results for a typical small hospital in San Francisco. To minimize total energy costs DER-CAM suggests operating the 500 kW reciprocating engine between 9am and 1pm to avoid high demand charges and to reduce electricity purchase costs. Profiles similar to figure 4 are generated for each month and each week, including weekends and the peak day. The user has full flexibility and can define these input-related data.

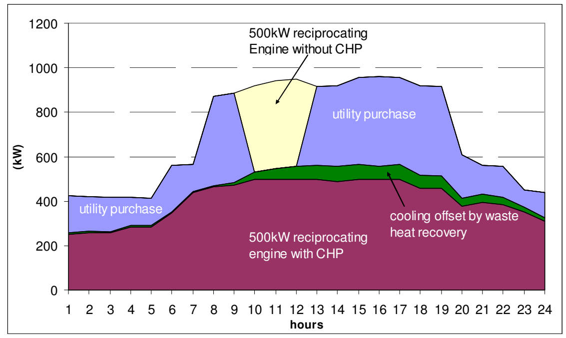


Fig. 4 Optimal Operation Schedule for a Typical Small Hospital in San Francisco

Future work will incorporate DG reliability related considerations as well as stochastic influences caused by future uncertainties (e.g. weather), and will expand on demand-side capability.

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For information about the required GAMS optimization software, please visit: www.gams.com

More information on DER-CAM can be downloaded at:
http://der.lbl.gov