Modeling Tools for Data Center Energy Performance and Sustainability

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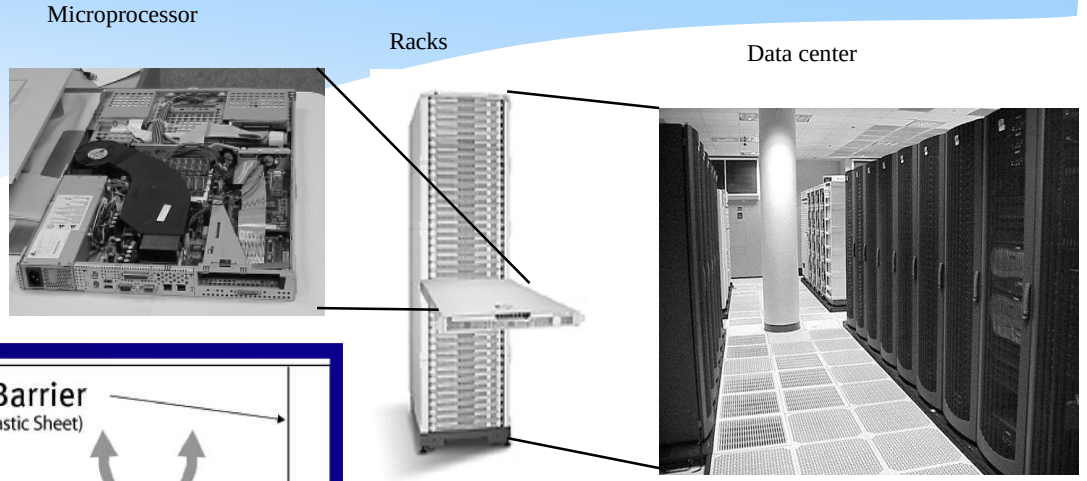
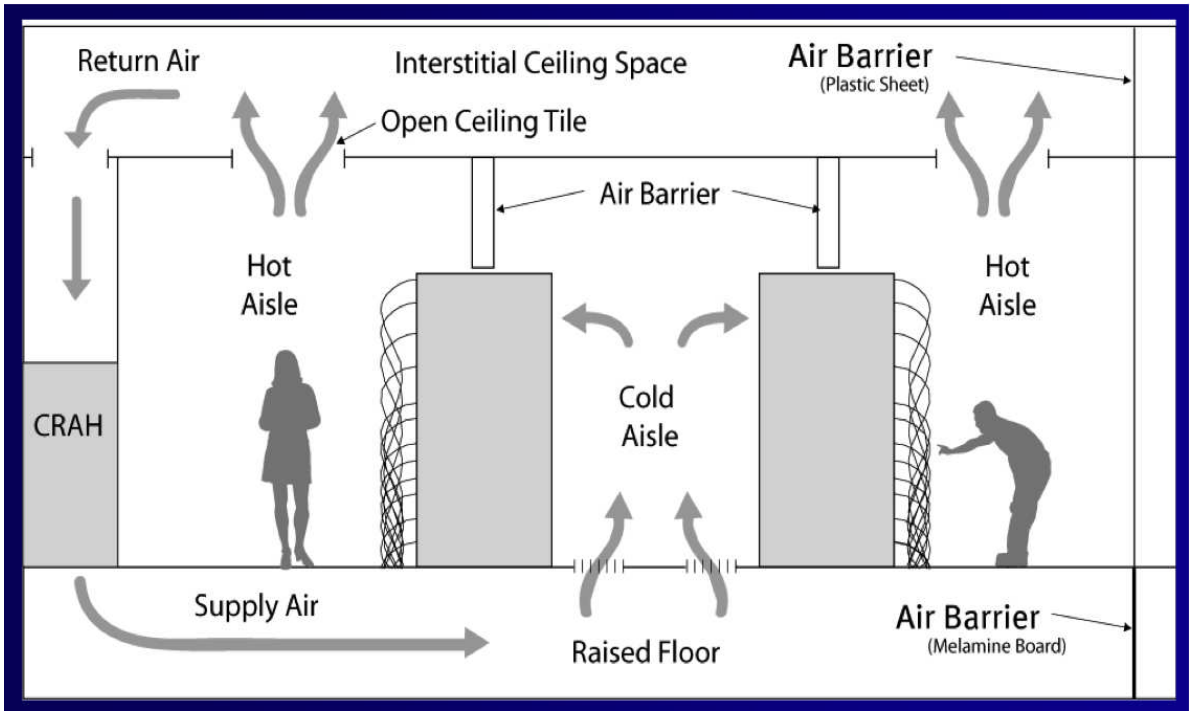




Vision:

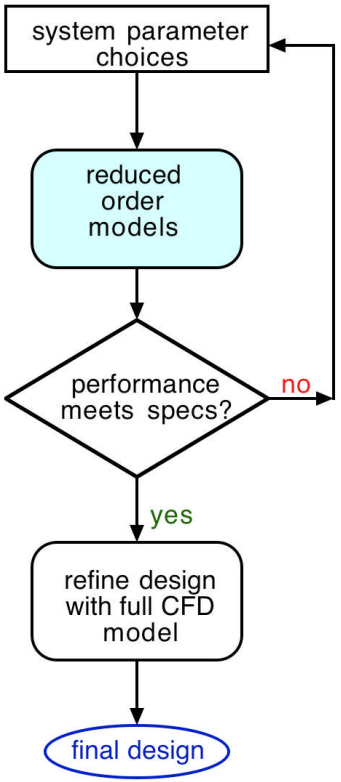
Fast, easy to use analysis software to predict data center energy performance

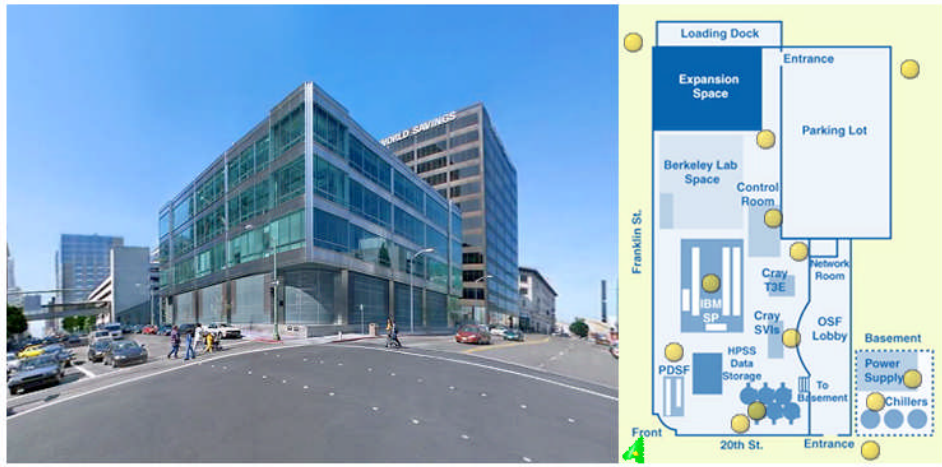
Fast compact models of data center energy performance

Uses:

- *Fast parametric optimization of new DC designs*
- *Integrate compact models into smart digital controllers*
- *Fast, easy assessment of evolutionary design changes*

Data Center Design Process





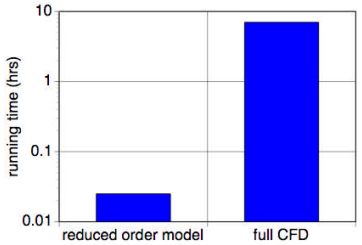
OSF- Oakland Scientific Facility (NERSC)

Reduced Order Models for Transport

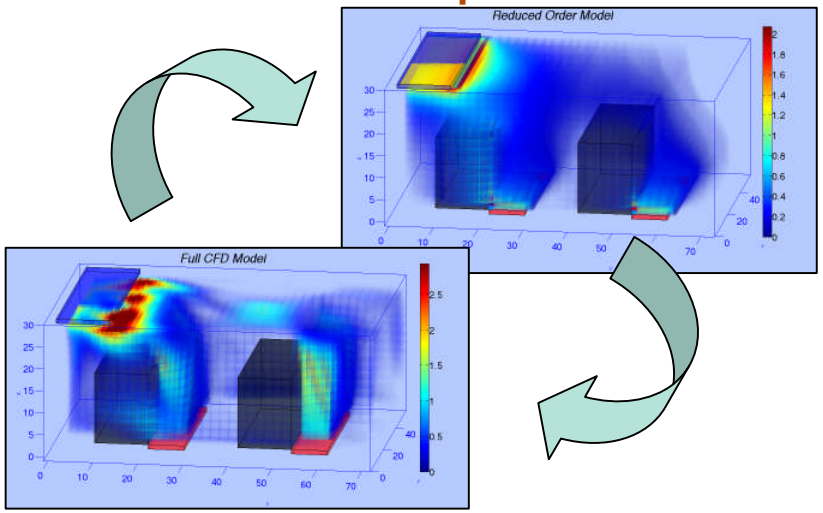
Numerically solve equations for
- air flow
- energy transport
- exergy transport and destruction

Use Matlab GUI Platform for Design

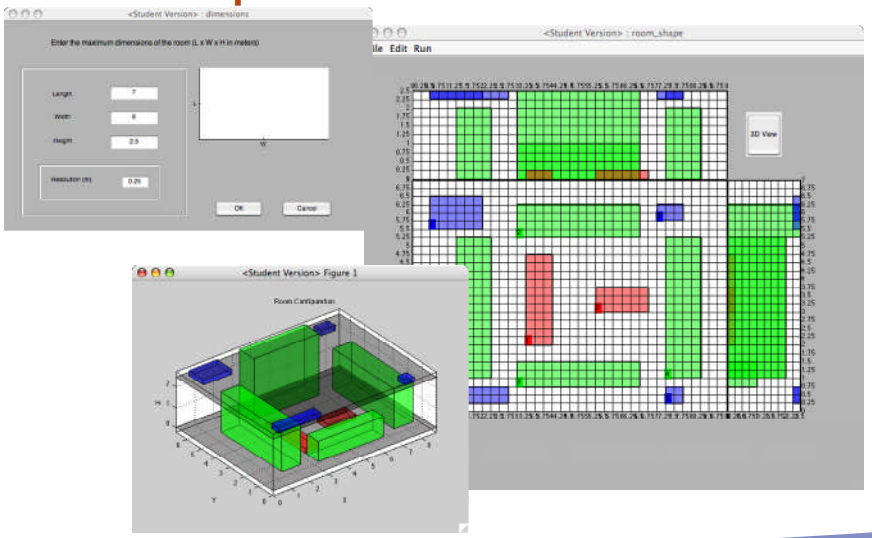
Use for
- rapid design analysis
- digital control



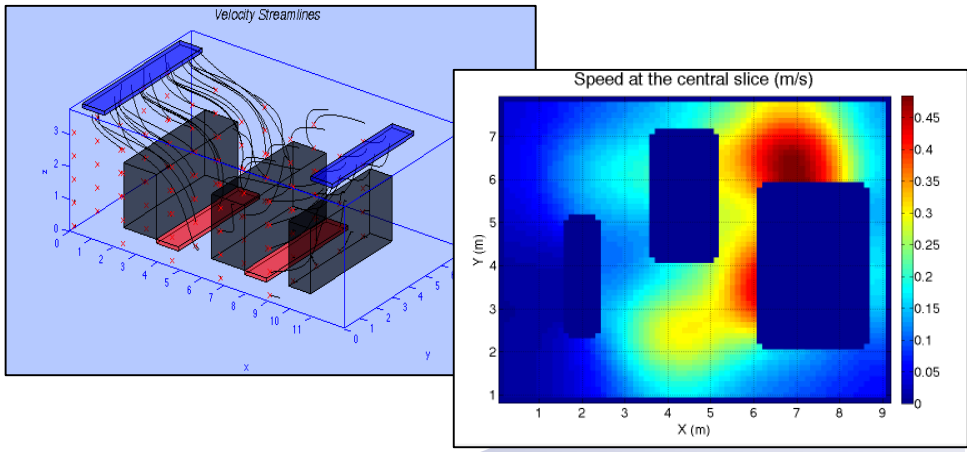
Assessment: Full CFD Comparison



Flexible Input Process



Visualization Tools Development



Exergy => (available energy) energy fully convertible to work

=> quantifies the **amount** of useful energy flowing (**quantity** and **quality**)

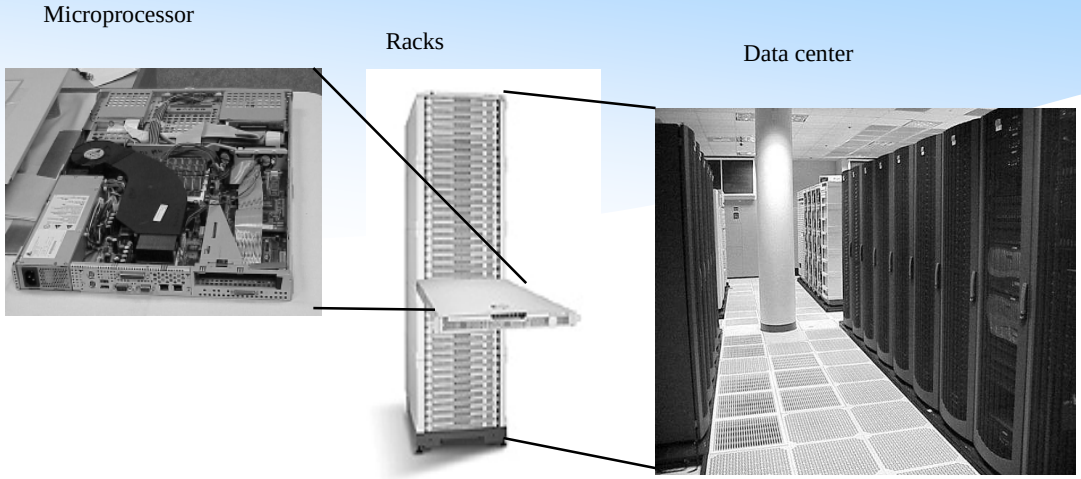
Energy flowing through the data center is not consumed, it is degraded

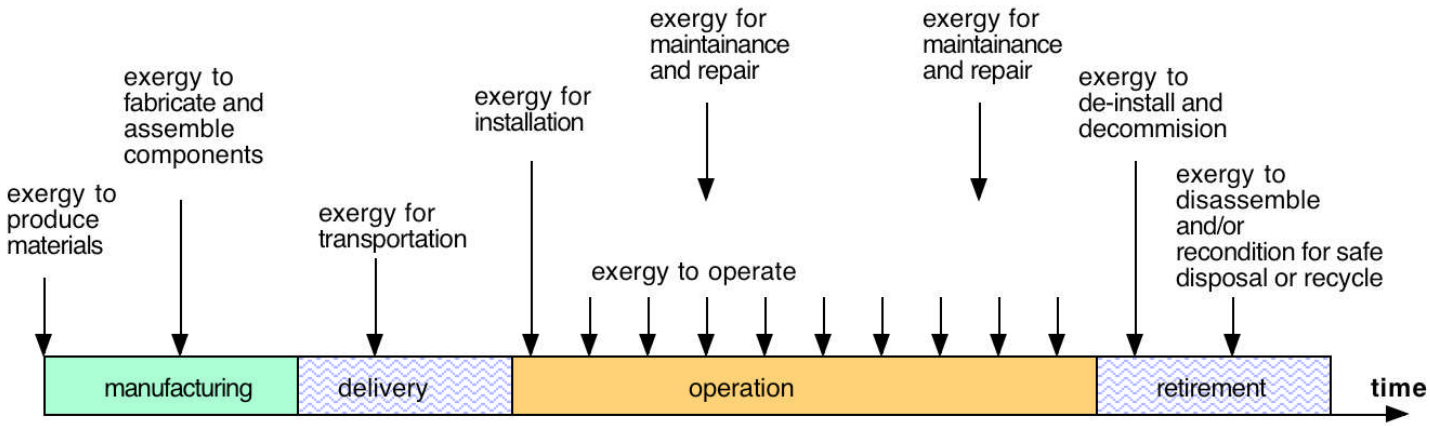
Electricity
(organized)

heat
(disorganized)

Modeling exergy destruction throughout the data center predicts where energy inefficiencies are greatest

Exergy destruction quantifies value of useful energy resources lost





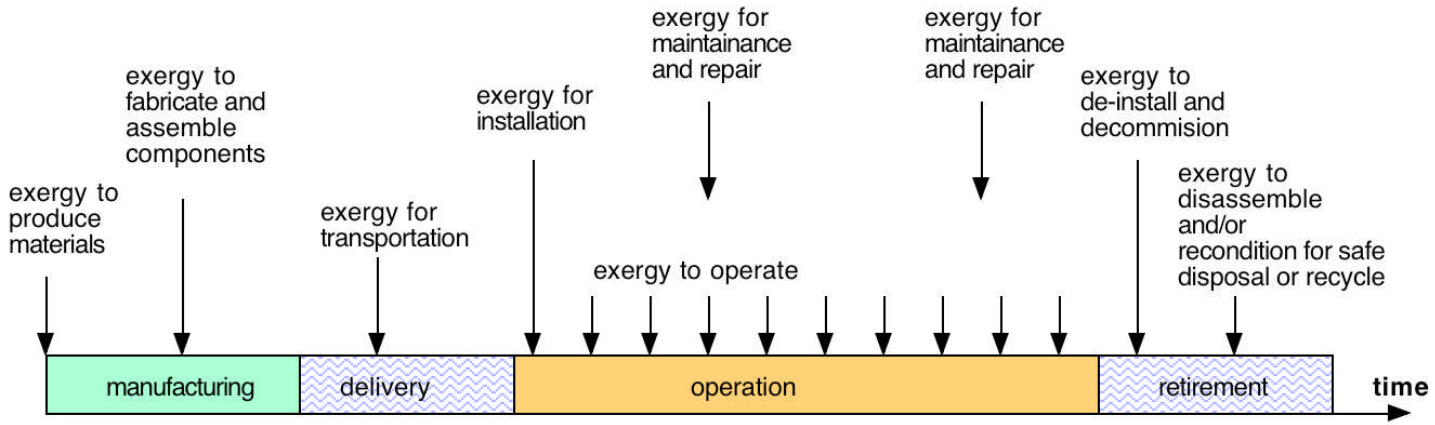
Vision:

Analysis tools to predict life cycle exergy consumption data for IT systems

Analysis tools to predict life cycle exergy consumption data for IT systems

Uses:

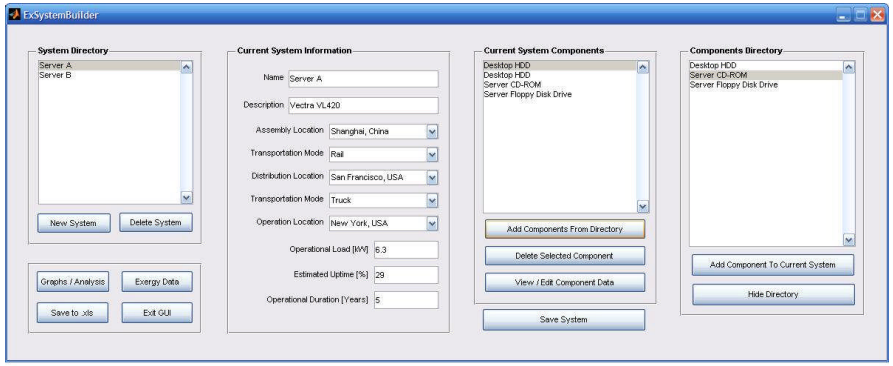
- *strategies to minimize lifecycle exergy consumption*
- *Highest exergy consumption elements are greatest sources of inefficiency – prime targets for improvement*

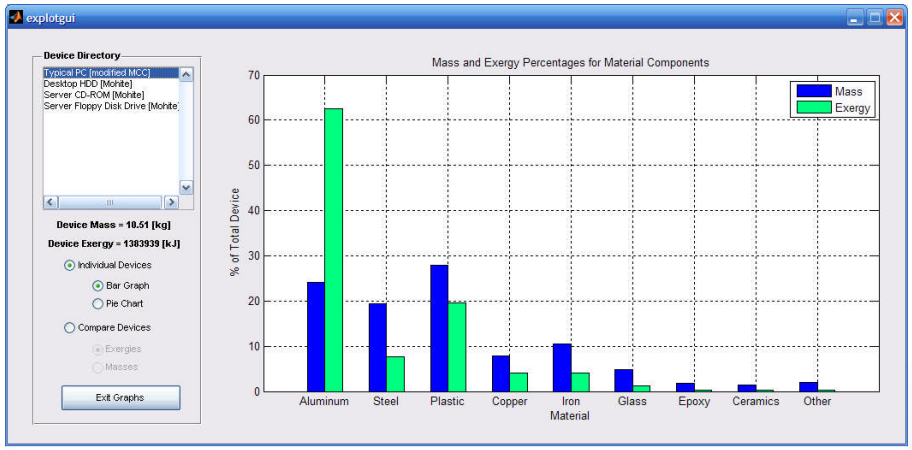


Tools to analyze lifecycle exergy consumption

Matlab GUI allows systems to be built in hierarchical manner

- Build system from component menu or customize
- Change transportation and operation parameters
- View and edit material compositions and exergy data





Preliminary analysis comparing material compositions

Use to:

- Compare different stages within a system's lifecycle
- Compare multiple systems

Tools to analyze lifecycle exergy consumption

Case Study

- **Server Details:**
  - **2U rack-mounted server**
  - **3-year operational lifetime**
  - **50% peak computational load**
- **Two Scenarios**
  - **Without scaled cooling**: cooling load is not able to scale to computational load, resulting in a 100% maximum cooling load at all times
  - **With Scaled Cooling**: cooling load is able to scale based on computational load, resulting in a 50% maximum cooling load for this study
- **Observations**
  - **Efficiency and flexibility of cooling infrastructure greatly influences total lifetime exergy consumption**
  - **Without scaling, the cooling load accounts for nearly 63% of the exergy consumption**