Building Energy Simulation – Sensitivity Analysis

University of Maryland, College Park
Mechanical Engineering Departments
ENME808i / ENME424 – Urban Microclimate and Energy
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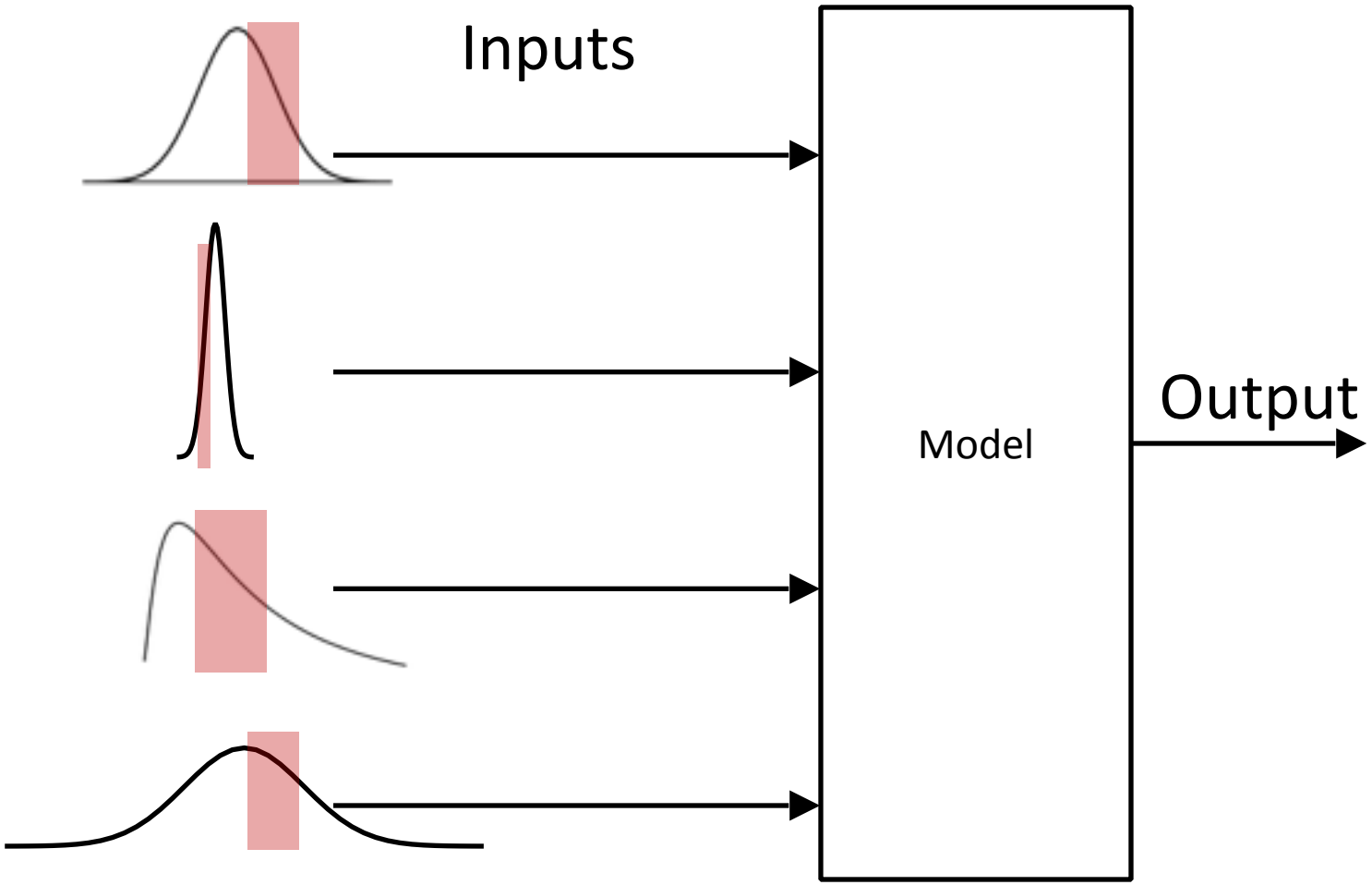
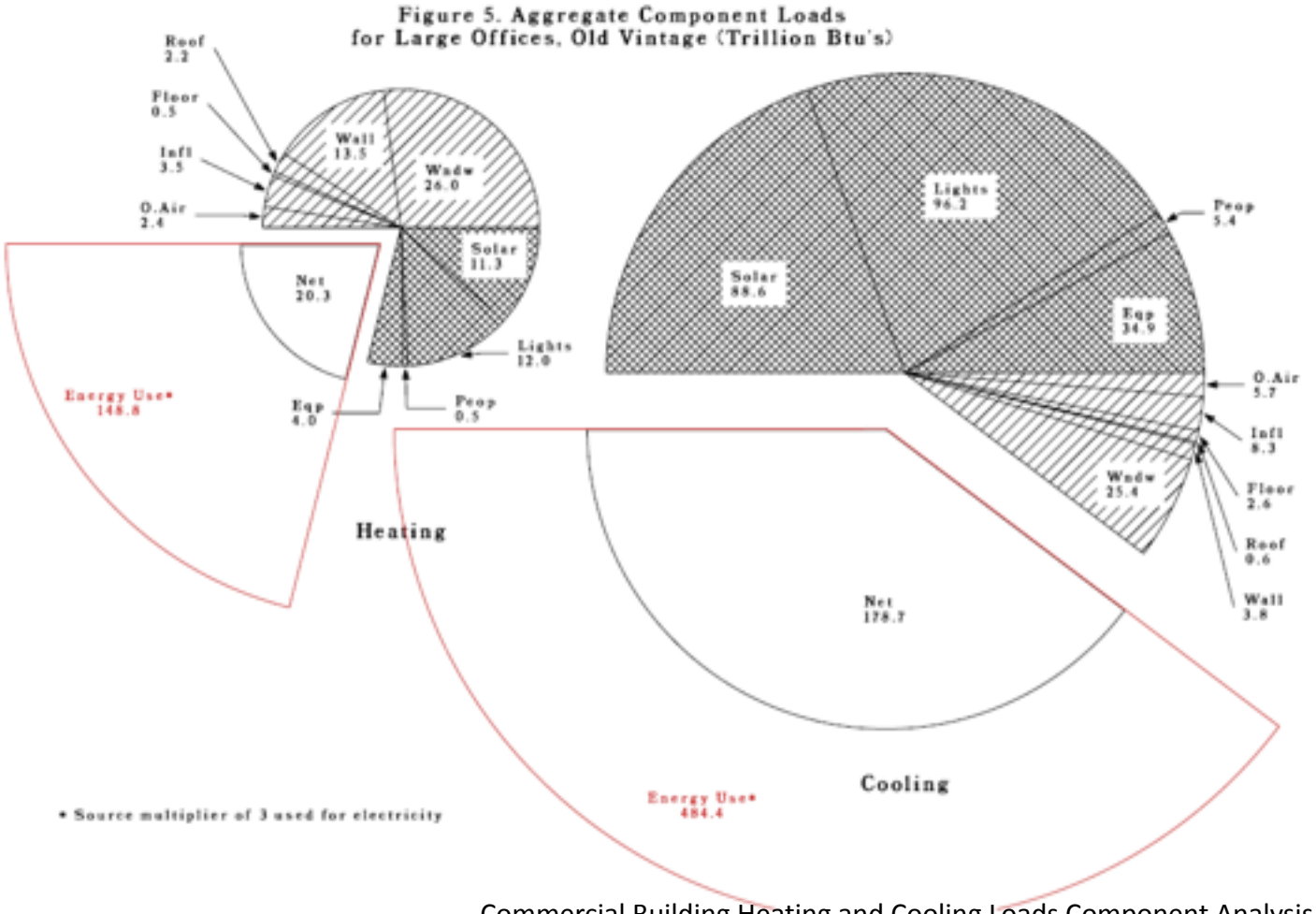
Jelena Srebric, Ph.D.

Abstract Model



Component Load Contributions



Commercial Building Heating and Cooling Loads Component Analysis - LBNL -1999

Sensitivity Analysis – Local Methods

- One-factor-at-a-time (+-20%, +- 1 standard deviation)

$$sensitivity = \frac{\Delta Y}{\Delta X_i}$$ For each parameter X_i, i = 1,…,n

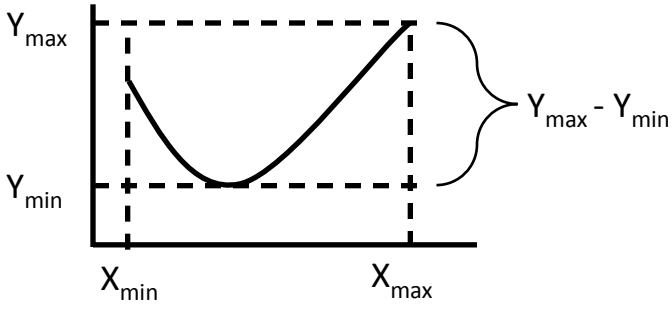
  - Only <u>local</u> variation; no interaction between parameters
  - Using standard deviation is preferred, but requires assuming a distribution (e.g. boiler efficiency 0.88 +- 20% can give an efficiency of 1.06!)

- Partial Derivatives

$$sensitivity = \frac{\partial Y}{\partial X_i}$$ For each parameter X_i, i = 1,…,n

- Sensitivity Index (Hoffman & Gardener 1983)

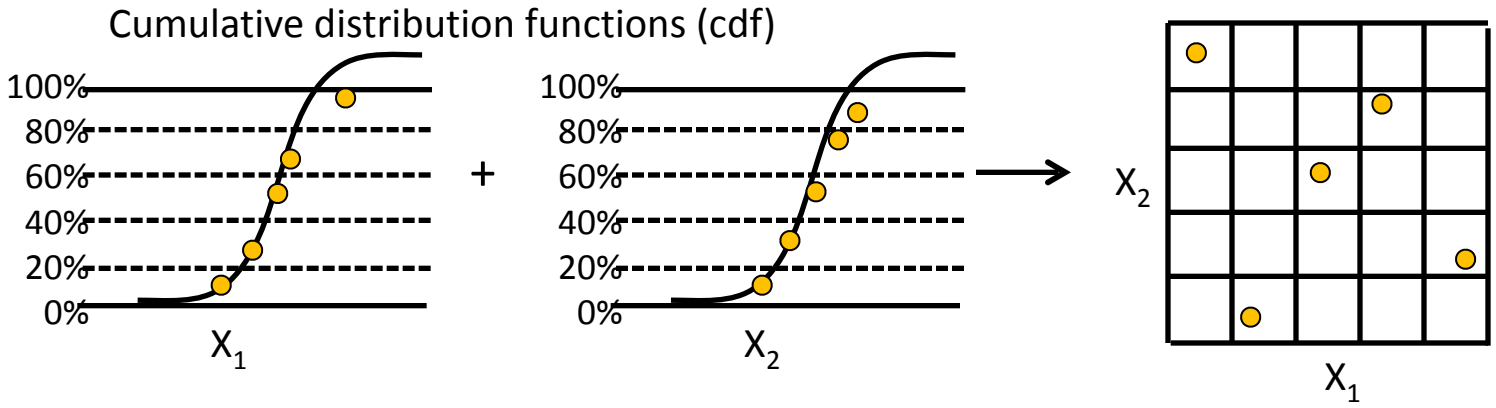
$$sensitivity = \frac{Y_{max} - Y_{min}}{Y_{max}}$$



Sensitivity Analysis – Global Methods

- Regression (using regression coefficients or partial correlation coefficients)

- Design of Experiments method, e.g. ANOVA with Blocking or Factorial Designs
  One of particular mention is Latin Hypercube Sampling (McKay 1979)



- NIST Engineering Statistics Handbook: http://www.itl.nist.gov/div898/handbook/pri/section3/pri3.htm

Wei Tian, A review of sensitivity analysis methods in building energy analysis, Renewable and Sustainable Energy Reviews, Volume 20, April 2013, Pages 411-419

Hints

Focus time on parameters that:

1) Energy use is very sensitive to the parameter
2) The parameter has a wide distribution of typical values and large uncertainty

For most commercial office buildings, these are:

-Temperature setpoints and setback schedule
-Plug load density and schedule
-Lighting load density and schedule
-Fan supply air temperature, static pressure rise, schedule
-Exterior lighting density and schedule

These can be very significant if much different from defaults:

-Heating equipment efficiency, cooling equipment capacity and efficiency
-Exterior wall R-value, window R-value, solar heat gain coefficient, window-to-wall ratio
-Infiltration
-Outdoor air minimum, minimum flow for terminal boxes

Ke Xu. PhD Dissertation. PSU 2012.
(see modeling resources for copy)