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Seminar 43: District and City Scale Modeling Using OpenStudio

Learning Objectives

- Learn how urban-scale building modeling can be used to make more well-informed energy decisions.

- Learn challenges of big data and computing for city scale building energy modeling

- Understand why metropolitan planning agencies are starting to become more interested in building energy use.

- Understand some ways a building energy model can be coupled to other metropolitan simulation tools.

- **Understand OpenStudio's capabilities for generating simulation models from high level user input.**

- **Understand the interactions between data collected in the SEED Platform through energy disclosure laws and city scale modeling with DECAF.**
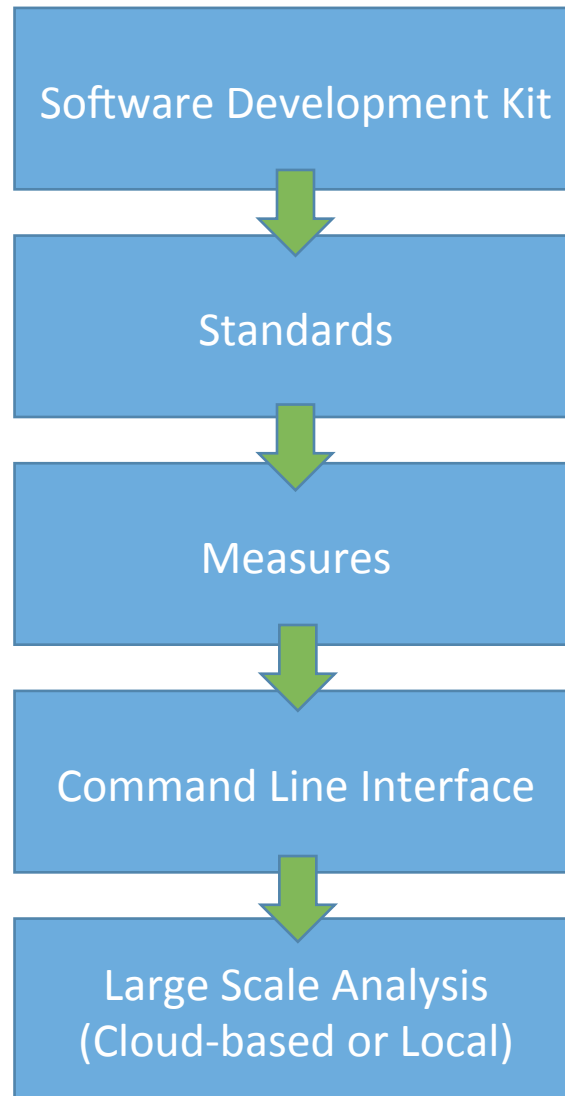
Acknowledgements

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- Open Energy Efficiency
- Lawrence Berkeley National Laboratory
- National Renewable Energy Laboratory

Outline

- OpenStudio Approach To Modeling
- Application 1: City Scale – SEED + DECAF
- Application 2: District Scale – URBANopt

The Software's Approach to Modeling

Software Development Kit

↓

Standards

↓

Measures

↓

Command Line Interface

↓

Large Scale Analysis
(Cloud-based or Local)

Software Development Kit (SDK)

- **Open Source, Cross-Platform, Multiple Languages**

- **Manipulate input models and access simulation results programmatically**

- **Manipulate convenient abstractions like space types, construction sets, etc.**

- **Single model access to Radiance, CONTAM and other engines**

- **Input and export gbXML, SDD, BuildingSync®**

Users see the graphical skin, but 90% of the software's investment is in the SDK...

The SDK is the biggest chunk of the iceberg below the surface
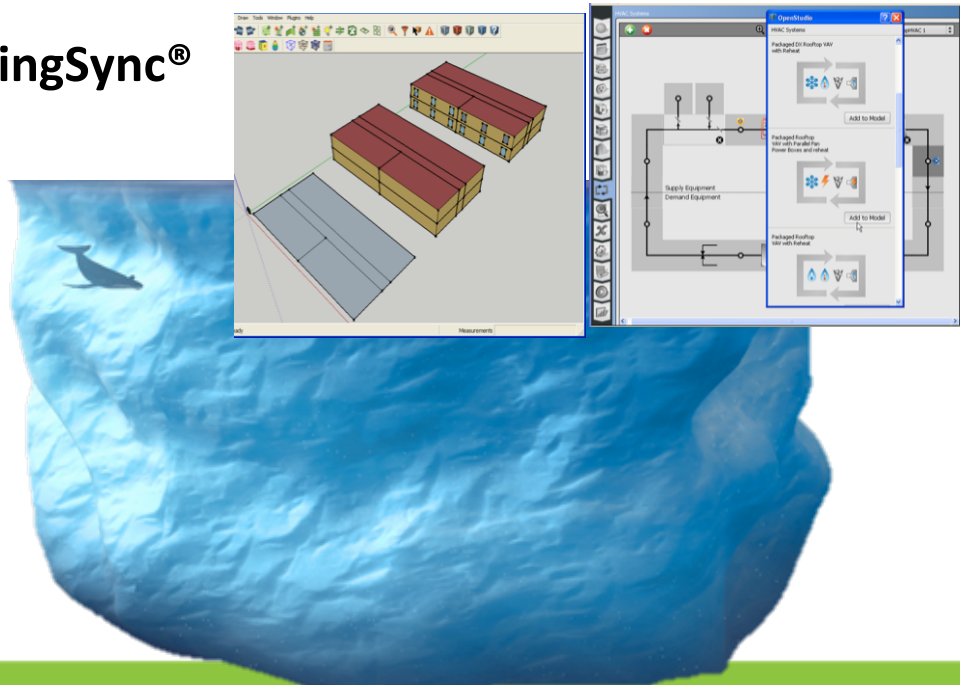
Codes & Standards

Efficient Lookup of Standards and Prototypical Data

- ASHRAE 90.1, Canadian NECB, Indian ECBC
- Standards Data including Lighting, Occupancy, Ventilation, HVAC Efficiency
- Prototypical Data including Schedules, Equipment Density, Thermostat Setpoints

The DOE Reference and Prototype Buildings in OSM Format

- Single measure creates ready to run model versions of the DOE Prototypes
- Open OSMs in the Application to inspect models
- Apply measures to prototypes for large scale studies, DOE SCOUT, or other applications

Baseline Automation

- Given an energy model, measure creates ASHRAE 90.1 App G. baseline
- Other standards can and are being added (Canadian NECB, Indian ECBC)
- Several collaborators are testing on real-world models

Model Articulation

- Data and methods in the standards library can be used to fill in smart defaults when detailed information is not available

Measures

Measures: scripts that operate on model & results

- Transform model *e.g.*, replace constructions, daylighting package, etc.
- Perform these actions repeatedly, consistently & quickly on any model
- An open way of extending functionality & transferring knowledge
- Can be arbitrarily surgical, *e.g.*, daylighting measure sensitive to space-type

Daylighting Package

Add Heat Recovery
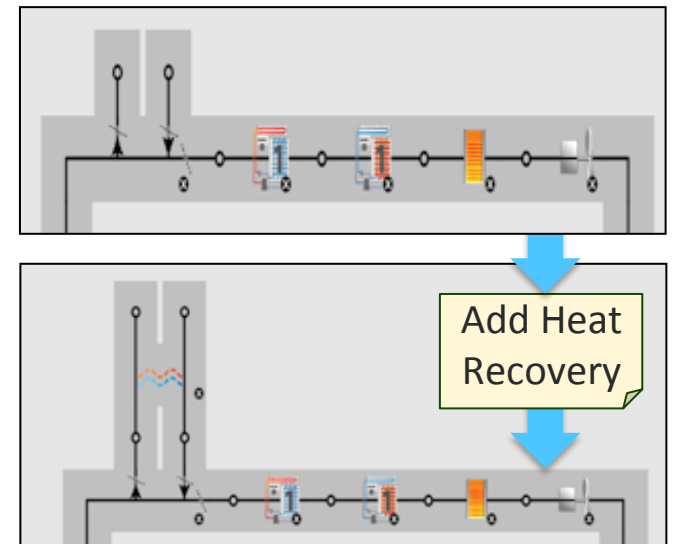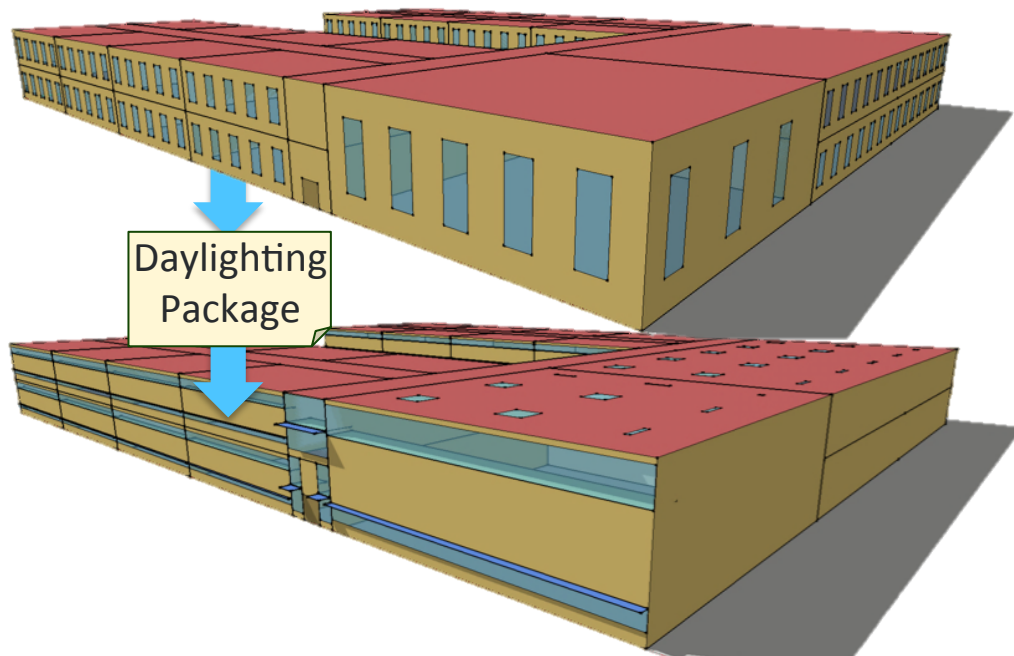
Command Line Interface (CLI)

Single statically linked command line interface executable
- "Do one thing and do it well" – Unix Philosophy

What's under the hood?
- OpenStudio.exe has all dependencies (including Ruby) built in
- Commands to create measures, compute arguments, run measure tests
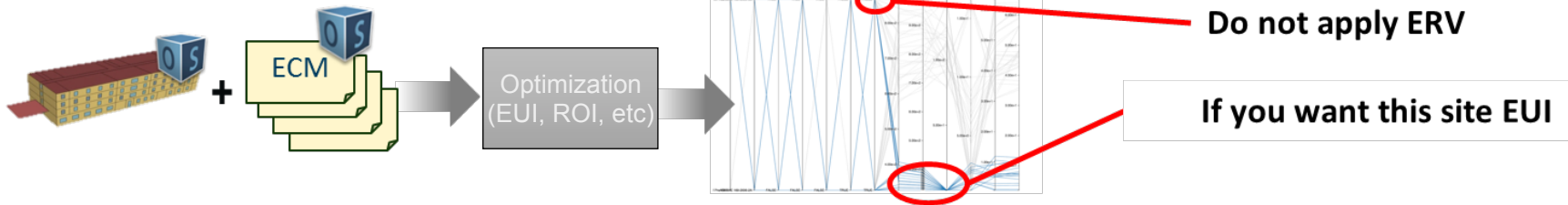- Command to run the new Workflow (OSW) format

What is OSW?
- Simple, JSON format for describing a simulation workflow
- *Load seed model, apply measures, run EnergyPlus, run reporting measures*
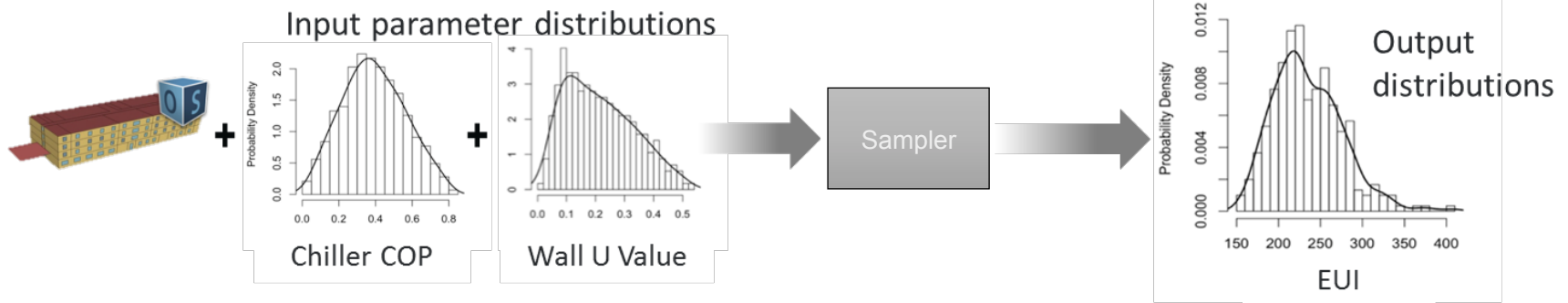
Eating our own dog food
- All of our applications are now users of the CLI
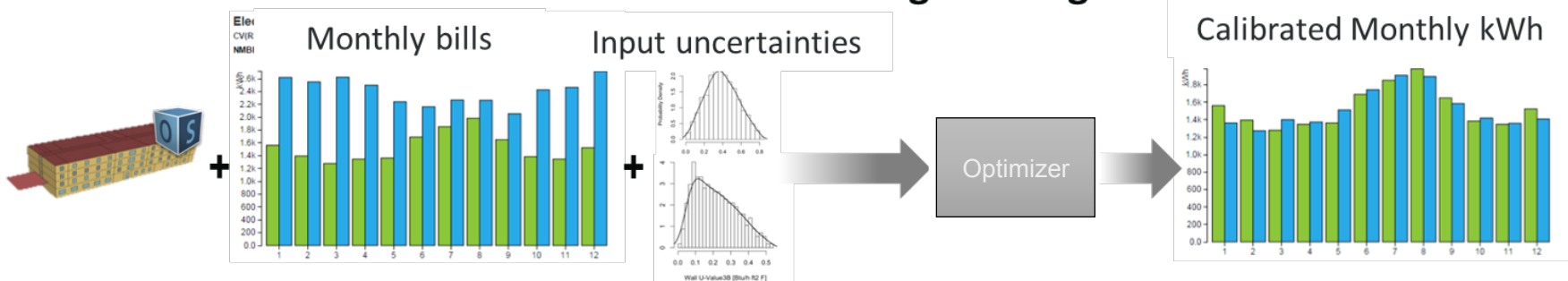
Large Scale (Cloud-based) Analysis

ECM package optimization

Measures   Outputs

Do not apply ERV

If you want this site EUI

ECM + Optimization (EUI, ROI, etc)

But also uncertainty analysis ➔ ranges instead of point estimates

Input parameter distributions

Chiller COP

Wall U Value

Sampler

Output distributions

EUI

And calibration ➔ Better estimates for existing buildings

Monthly bills

Input uncertainties

Optimizer

Calibrated Monthly kWh

Application 1: City Scale

Targeted Energy Efficiency Marketing

- Analyze individual buildings at the city scale
- Screen buildings for highest potential savings
- Plan client site visit to review initial savings and ROI
- Gather information, rerun analysis, select package
- Perform retrofit, M&V, validate recommendations

Application 1: City Scale

Portland building footprints

- Significant data on the existing built environment is in the public domain

- Building footprints, height, and zoning are commonly available

- Energy disclosure laws provide actual use

- Public data is inconsistent and varies from city to city

City	Foot-print	Area	Num Stories	Height	Type	Address
San Francisco	Yes[1]	No	No	Yes[1]	Yes[2]	No
Denver	Yes	No	No	Yes	Yes[2]	No
Portland	Yes	Yes	Yes	Yes	Yes[2]	Yes

Summary of public data for three cities

Application 1: City Scale

SEED
STANDARD ENERGY EFFICIENCY DATA
PLATFORM™
U.S. DEPARTMENT OF ENERGY

**Inaugural Partners**

Atlanta, GA	Houston, TX
Berkeley, CA	Kansas City, MO
Cambridge, MA	New York City, NY
Salt Lake City, UT	Orlando, FL
Washington, D.C.	Philadelphia, PA
Montgomery County, MD	
California Energy Commission	

- Designed to manage building performance data for cities with energy benchmarking ordinances

- Combines data from multiple sources, cleans and validate it, as well as generating queries and reports.

- Compiles information on the building stock in one place using standard terms

- Combining building information with measured energy usage enables us to close the loop between modeled and measured energy use

Application 1: City Scale

Public and private data

SEED

User Interface

Large Scale Analysis*

Server(s)
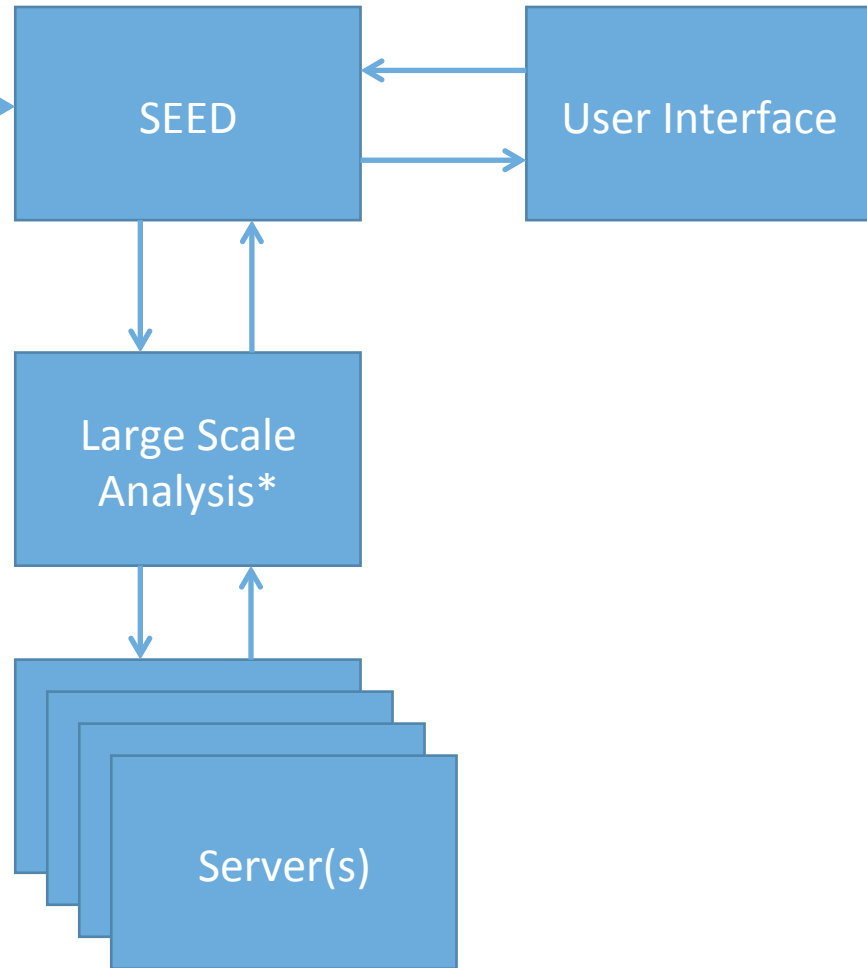
*New name is forthcoming

Application 1: City Scale

- Association of Bay Area Government
- Evaluate deep, targeted retrofits for 5,000 small/ medium commercial buildings in Bay Area
- FY17 Evaluate targeted retrofits for 5,000 small/ medium commercial buildings in Bay Area
- FY18 Enroll at least 100 buildings in enhanced retrofits
- FY19 M&V comparison of actual vs simulated savings

Application 2: District Scale

- Federal, state and local governments have aggressive energy and carbon reduction targets

- District revitalization projects provide economic and quality of life benefits in addition to energy savings

- Need for a design tool that can consider existing buildings, new construction, residential, commercial, district systems and community renewables

"The district is the optimal scale to accelerate sustainability—small enough to innovate quickly and big enough to have a meaningful impact." - EcoDistricts

Application 2: District Scale

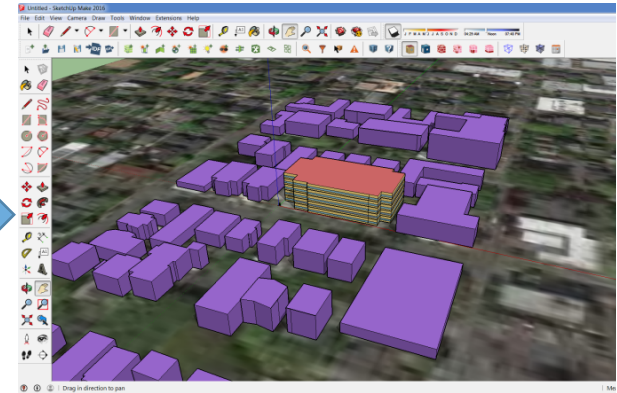Overall architecture of the OpenStudio City Modeling Framework. Components can be used together or separately
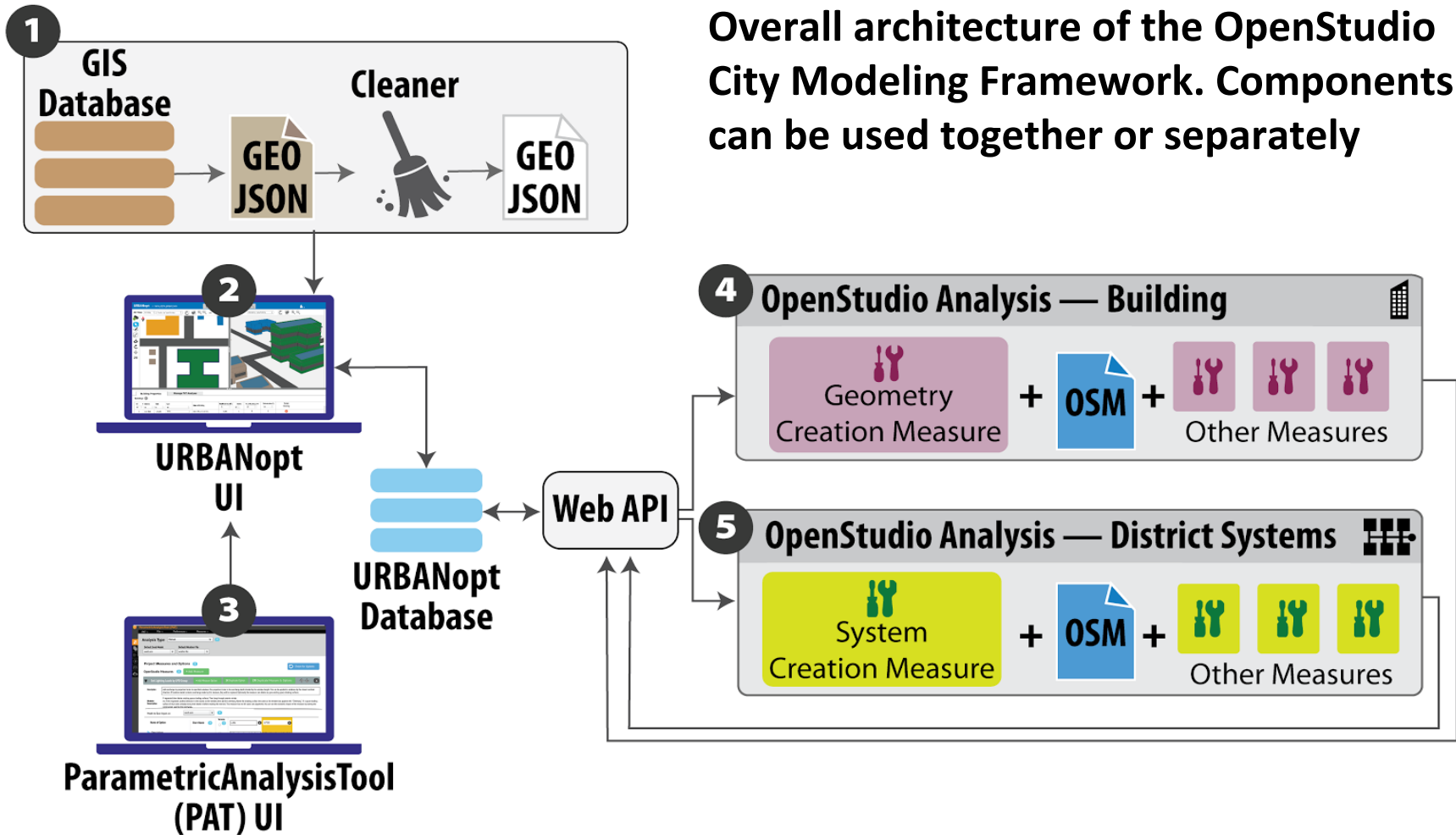
Application 2: District Scale
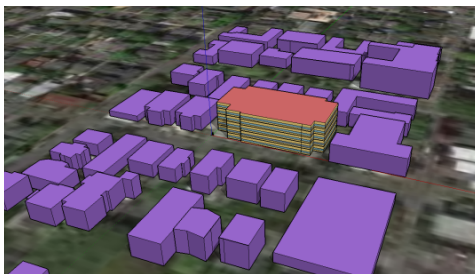
Footprint, type, height
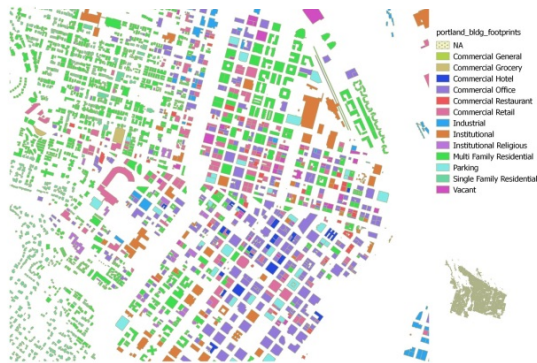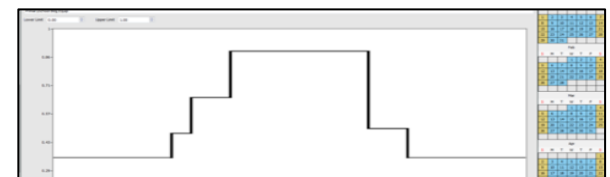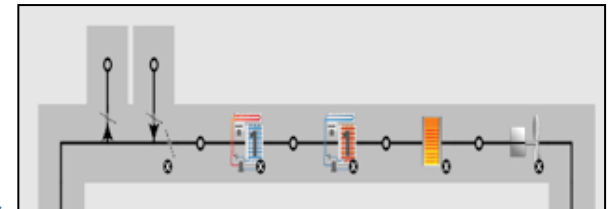

Building geometry

Geometry Creation Measure

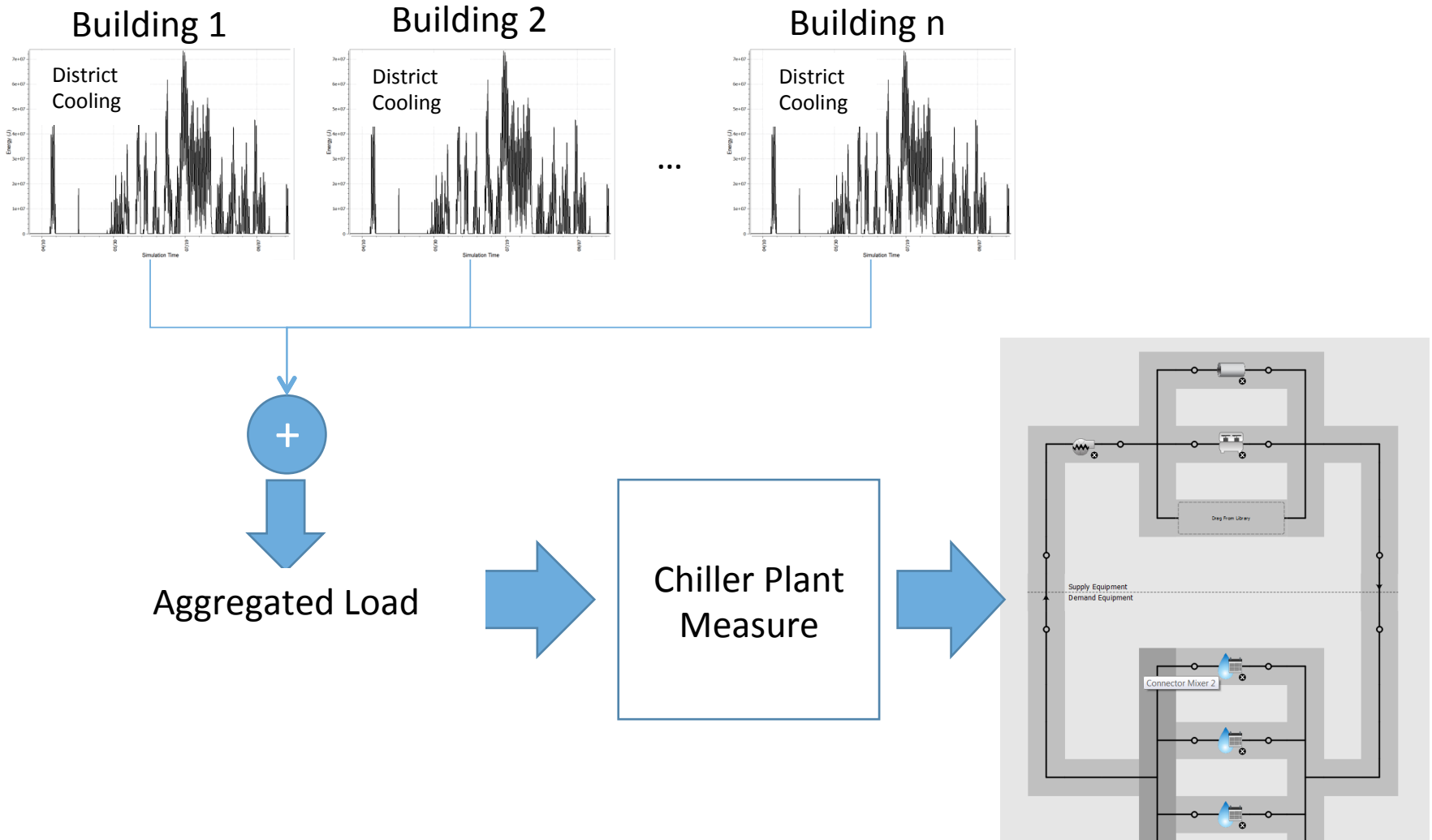Primary fuel types

Building geometry

Building Type Measure

(OpenStudio Standards)

Prototypical Constructions, Loads, Schedules, HVAC

Application 2: District Scale

Conclusions

- In addition to detailed modeling based off of large amounts of data, the OpenStudio platform can be used to generate models based off of minimal data

- Modeling approach can be applied at the city scale to provide targeted marketing of energy efficiency

- Modeling approach can be applied at the district scale to analyze different scenarios including district energy systems

QUESTIONS?

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