**Project Summary**

**Timeline:**
- Start date: **Q1 FY10**
- Planned end date: **Ongoing w/ Frequent Off-Ramping of Components**

**Key Milestones:**
1. V1.1 (Cloud) – 9/27/2013
2. V1.2 (Refrigeration) – 12/20/2013

**Budget:**
- Total DOE $ to date: **$7,655,000*\)**
- Total Cost Share to date: **$4,691,000*\)**
- Total future DOE $: **$3,500,000*\)**

**Target Market/Audience:**
- **Tool Developers**, A&E Practitioners, Utilities, Researchers, and Students

**Key Partners:**

<table>
<thead>
<tr>
<th>Key Partners</th>
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</thead>
<tbody>
<tr>
<td>All BTO Labs</td>
<td>NRCan/NRC</td>
</tr>
<tr>
<td>CEC</td>
<td>concept3D Inc.</td>
</tr>
<tr>
<td>BPA</td>
<td>PSD Consulting</td>
</tr>
<tr>
<td>Xcel Energy</td>
<td>Multiple Universities</td>
</tr>
<tr>
<td>National Grid</td>
<td>Other Private Sector Companies</td>
</tr>
</tbody>
</table>

**Project Goal:**
Develop BTO’s best-in-class building energy analysis ecosystem to enable rapid, low-cost development of new market facing tools produced by the National Laboratories, Universities, Private Sector, and other agencies.

Facilitate successful deployment of the software development kit across BTO performers, utilities, and private sector developers to drive real energy savings in new construction and retrofit projects.

* Includes OpenStudio Core, Asset Score, and related OS Projects
Problem Statement

Q: What collection of software technologies will make energy modeling less costly, more accessible, increasingly reliable, and ubiquitous for the broad range of stakeholders who rely on analysis to make business decisions for their new construction and retrofit portfolios?

A: DOE’s OpenStudio ecosystem.
Target Market and Audience

The market for OpenStudio is diverse and includes:

- Tool developers* that are able to quickly and cost-effectively bring new software innovations to market;
- A&E practitioners that use the example applications to reduce energy consumption for new construction and retrofit projects;
- Utilities that are trying to reduce the cost of incenting EE, realize greater EE savings, and assess technology potentials;
- Researchers who are trying to design and assess new technologies; and
- Students who are the next generation of building designers.

* This is OpenStudio’s biggest growth area in FY13/14
Partial List of Partners
Real Market Adoption = Real Impact

• For Xcel Energy’s new construction program OpenStudio is directly contributing to its program savings goal of 40 GWH (up from 30 in 2013)

• Increasing cost-share from private sector

• Example models from practitioners:

![Graph showing FY10-14 Budgets* ($k)](image)

Roland Garros Airport Near Madagascar
Patrick Bivona - Artelia

Eric Studer, PE
TNZ Energy Consulting, Inc.

Southern Utah University and University of Colorado, Denver
Approach to Development and Deployment

Approach:

• Development team uses an “agile” software development process
  – Formal task and bug tracking systems
  – Automated nightly software build, test, and dashboard system
  – Formal processes for design document and code reviews
• Frequent vetting of UI concepts and workflows with external stakeholders

Distinctive Characteristics:

• Flexibility to quickly produce new desktop, mobile, and web tools that are easily integrated with one another
• Agile process allows focus to change as new requirements emerge
• Rigorous approach to creating software for the marketplace - not a research project
Adapting to Changing Needs

Increased Focus on Collaboration:
- Inclusion of non-NREL developers drove more process formalism
- New processes for better code sharing -> Canary in the coalmine for EnergyPlus
- Greater transparency of development plans on website
  - Key features
  - HVAC roadmap
  - Measures roadmap

Embracing Agile:
- HVAC coverage initiatives driven by CEC, Xcel, and other market actors
- New software technologies have enabled a more extensible, scalable OpenStudio analysis framework that works well in the cloud
- Solution is enabling us to deliver optimization capability along with our AOP objectives for parametric uncertainty analysis
Significance: Practitioners now have access to scalable computing resources on par with National Laboratories allowing them to consider more measures in less time.
Significance: Practitioners and researchers can now easily assess the impact of uncertainty on energy efficiency for a broad range of parameters.
Major Accomplishment – Optimization*

**Significance:** Practitioners and researchers can now easily optimize measures and associated parameters for design or to calibrate models.

- Multiple algorithms (easily extended via R)
- Supports discrete and continuous variables
- Customizable multi-objective optimization
- Interactive visualization tools built into OS Server help explore large solutions spaces

*Not an AOP deliverable, but something the new analysis framework allowed us to deliver with little additional effort.
Major Accomplishment – Extensible Results Reporting

Significance: Practitioners can now easily extend the OpenStudio application with their own custom reports via reporting measures.
Major Accomplishment – Additional HVAC Systems

Significance: Much progress made on exposing the breadth of EnergyPlus’ HVAC modeling capabilities as prioritized by project needs.

New systems include:
- Variable Refrigerant Flow
- Plenums
- Ground Source Heat Pumps (Vertical Well)
- Chilled Beams
- Exhaust Fans
- Radiant Slabs
- Baseboard Heating
- Demand Control Ventilation
- Many more complete or in process
Major Accomplishment – Commercial Refrigeration

Significance: Commercial refrigeration modeling is now “drag-and-drop” easy.
Major Accomplishment – CEC Title 24 Compliance Tool

- Version 1 of CBECC-Com certified 9/2013
- Certification for version 2 expected 4/2014
concept3D Inc. and simuwatt Energy Auditor

Benefits

- Streamlined, high quality commercial energy audits (Level II, III)
- Lower the cost of energy audits by 35-75%
- Consistent, standardized and reusable data format
- Access data from the cloud and share projects
- Custom reporting and output
- Asset tracking and building lifecycle tracking
- Opportunity for benchmarking and portfolio tracking
simuwatt Cloud and Applications

3rd Party Data

NREL Modeling Engine/Tools

simuwatt
Portfolio Manager

simuwatt
Library

simuwatt
Solar

simuwatt
Auditor
simuwatt Energy Auditor Workflow Overview

- OpenStudio automatically generates a detailed energy model ready for simulation
simuwatt Energy Auditor Workflow Overview

• Life cycle analysis identifies most cost-effective measures
simuwatt and OpenStudio produce the complete model needed for rigorous energy analysis.
Electricity Consumption (kWh)
CV(RMSE) = 6.37
NMBE = 1.53

Natural Gas Consumption (therms)
CV(RMSE) = 7.28
NMBE = 2.78

• OpenStudio assists with rapid model calibration
simuwatt Energy Auditor Case Study

### Simulation results compare:
- EUI and peak demand savings
- Gas and district heating/cooling impacts if appropriate
- Capital cost increases
- Annual utility cost savings
- Simple payback
- Total life cycle cost savings

### Auto-generated report
creates standard plots, text, etc. to save even more time

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<th>Peak Electric Demand Reduction (kW)</th>
<th>Electric Savings (kWh)</th>
<th>Natural Gas Savings (Million Btu)</th>
<th>District Cooling Savings (Million Btu)</th>
<th>District Heating Savings (Million Btu)</th>
<th>First Year Capital Cost Increase ($)</th>
<th>Annual Utility Cost Savings ($)</th>
<th>Simple Payback (years)</th>
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*U.S. DEPARTMENT OF ENERGY*

*Energy Efficiency & Renewable Energy*
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<th>Solar</th>
<th>Utilities</th>
<th>State/Local/Federal/non-profit</th>
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<tr>
<td>Johnson Controls</td>
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<td>Xcel Energy™</td>
<td>NREL</td>
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<td>NORESCO Honeywell</td>
<td>CIVIC SOLAR</td>
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</table>
Project Integration and Collaboration

**Project Integration**: OpenStudio platform directly enables the development of other National Laboratory products and private sector applications identified on previous slides. OpenStudio is also a critical component for CEC, NRCan, and multiple utility initiatives.

**Communications**:
- Active communication via:
  - [http://openstudio.nrel.gov](http://openstudio.nrel.gov) website and forums
  - OpenStudio YouTube channel with over 100 tutorial videos
- Multiple training opportunities offered by private sector performers
- Presentations at Fall eSource Forum and follow up scheduled for June
- Upcoming workshop at eSim in Ottawa Canada
- Papers presented at IBPSA SimBuild 2013
- Upcoming publications at:
  - eSim in Ottawa Canada
  - ACEEE Summer Study
  - IBPSA SimBuild 2014
Next Steps and Future Plans

1. Increased alignment (process and technology) with EnergyPlus 8.2
2. Ensure successful development, deployment, and adoption of platform-based tools
3. Expanded capability for rapid baseline modeling
4. Improve linkages between TPEx and BCL and the modeling ecosystem to enable assessment and adoption of ET
5. Leverage distributed analysis framework to support creation of large pre-computed simulation database (DEnCity)
6. Expand available measures (ECM, reporting, QA/QC) in BCL to further drive down the cost of modeling
7. Continue to increase cost-share and off ramp as value propositions expand for other agencies and utilities
Thank You!

Dr. Brian Ball (NREL)
Kyle Benne (NREL)
Dr. Katherine Fleming (NREL)
Dr. Elaine Hale (NREL)
David Goldwasser (NREL)
Luigi Gentile Polese (NREL)
Rob Guglielmetti (NREL)
Matt Leach (NREL)
Nicholas Long (NREL)
Dan Macumber (NREL)
Andrew Parker (NREL)
Marjorie Schott (NREL)
Alex Swindler (NREL)
Evan Weaver (NREL)
Jason Turner (Empty Crate Software)
Mark Adams (ORNL)
Xia Fang (Group 14)
Dr. Ralph Muehleisen (ANL)
Brian Craig (ANL)
Dr. Jason DeGraw (PSU)
Phylroy Lopez (NRCan)
REFERENCE SLIDES
Project Budget

**FY14 Spend** ($k)

Additional Scope Added for DEnCity

**FY10-14 Budgets** ($k)

* FY14 Spend and Budget Includes OpenStudio Core, Refrigeration GUI, and Asset Score CBI Budgets
## Project Plan and Schedule

### Project Initiation Date:
Q1/FY10

### Planned Completion Date:
Ongoing with Frequent Off-Ramping of Components (e.g. training transitioned to private sector in Q1 FY14)

### Release Schedule:
- Bi-weekly (Agile) Minor Releases
- Quarterly Major Releases with DOE-Prescribed Focus Areas

### Milestones & Deliverables

#### Project Name: OpenStudio Core

<table>
<thead>
<tr>
<th>FY2012</th>
<th>FY2013</th>
<th>FY2014</th>
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<tbody>
<tr>
<td>Q1 (Oct-Dec)</td>
<td>Q2 (Jan-Mar)</td>
<td>Q3 (Apr-Jun)</td>
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<td>Q4 (Jul-Sep)</td>
<td>Q1 (Oct-Dec)</td>
<td>Q2 (Jan-Mar)</td>
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<tr>
<td>Q3 (Apr-Jun)</td>
<td>Q1 (Oct-Dec)</td>
<td>Q3 (Apr-Jun)</td>
</tr>
<tr>
<td>Q4 (Jul-Sep)</td>
<td>Q1 (Oct-Dec)</td>
<td>Q4 (Jul-Sep)</td>
</tr>
</tbody>
</table>

- Q1 Milestone: OpenStudio 0.6 Released (Initial BCL Integration with OpenStudio)
- Q2 Milestone: OpenStudio 0.7 Released (First Version of OpenStudio App with BCL Integration)
- Q3 Milestone: OpenStudio 0.8 Released (App Suite Workflow Improvements and DEnCity)
- Q4 Milestone: OpenStudio 0.9 Released (BIM Interop and Initial Support for BCL Measures)
- Q1 Milestone: OpenStudio 0.10 Released (Sim Settings Tab and Backend Work for PAT)
- Q2 Milestone: OpenStudio 0.11 Released (Initial Version of PAT and BCL UGC)
- Q3 Milestone: OpenStudio 1.0 Released (PAT Economics and Measures)
- Q4 Milestone: OpenStudio 1.1 Released (Cloud Support and additional Measures)
- Q1 Milestone: OpenStudio 1.2 Released (Commercial Refrigeration Systems)
- Q2 Milestone: OpenStudio 1.3 Released (HVAC, Refrigeration, and OS Server Improvements)
- Q3 Milestone: OpenStudio 1.4 Released (OS Server Workflow and HVAC Improvements)
- Q4 Milestone: OpenStudio 1.5 Released (HVAC and Performance Improvements, DEnCity Development)