STANDARDIZING ENERGY MODELING OUTPUT

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ABSTRACT

Energy analysis programs are becoming more advanced and energy standards are becoming more stringent. This is driving more design teams to use a performance approach to comply with codes or to qualify for incentive and recognition programs. Each software application produces output in a different format and each code authority or energy program administrator requires that information be submitted in a different format. Energy modelers spend considerable time translating software results in to a suitable format for the program administrator.

This paper recommends a standard results format to serve as a sort of Rosetta Stone to ease and facilitate communication between energy modelers and energy program administrators. The standard format is electronic and defined as an extended markup language (XML) schema. Each software application can write simple routines to port their results to this format and each program administrator can write simple parsing routines to read the standard XML format and transfer it to their database format.

THE PROBLEM

There are a multitude of energy analysis programs that are used for building energy simulation and each software application stores information in its own format and generates reports that are formatted differently. At the same time there are a multitude of energy programs that depend on energy simulations. Some are recognition programs like LEED, Green Globes or Design to Earn ENERGY STAR where points or credit is earned by designing a building where the model predicts annual energy use (or cost) to be lower than a code defined baseline. Many energy utilities and Regional Energy Efficiency Organizations (REEOs) operate incentive programs that offer cash or other incentives for building owners to design their buildings to be better than a defined baseline and the claims are justified through simulations. Asset rating systems like the DOE Asset Score, ASHRAE Building EQ, California's BEARS, are based on energy simulations. Furthermore, California and some local governments are creating databases on the energy performance of buildings in their jurisdiction.

Since each software application has a different form of output and most of the energy programs want this information translated into a format that they can use and is compatible with their database, energy modelers and others spend a lot of time filling out forms and transferring data. Not only is this time consuming but it is results in careless mistakes and errors. The current process is diagrammed in Figure 1. Each line between software applications and energy program databases is a separate data transfer effort.

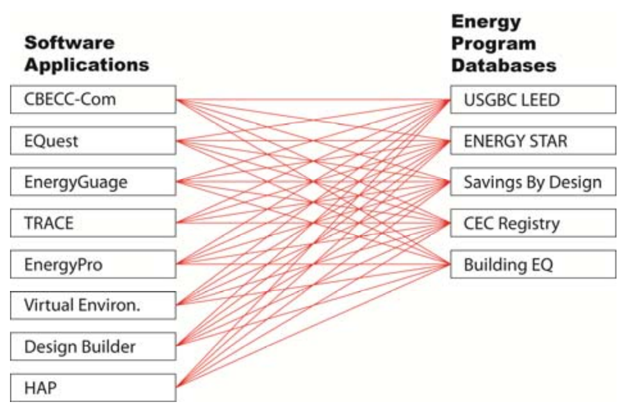

Figure 1 – The Inefficient and Error-Prone Existing System of Data Transfer

Conceptually, the solution is fairly simple. What we need is a common electronic data format that all the software applications can write to and all the energy programs can read from. This simple solution is depicted in Figure 2. This paper is about the advantages of standardizing on such a format, some existing formats that might be either used or adapted to be the standard format, and what the process should be for developing a standard format.

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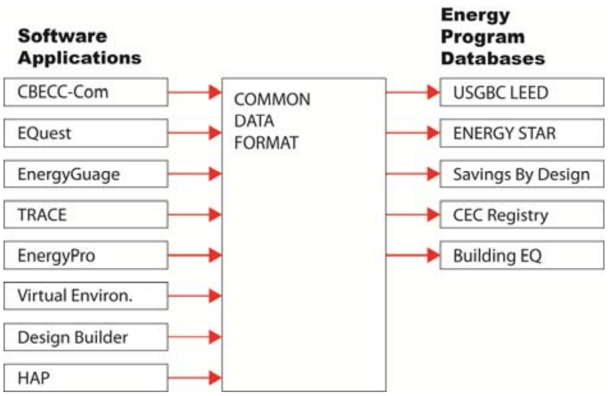

Figure 2 –Data Transfer with the Use of a Standard Data Format

XML AND SCHEMAS

The EXtensible Markup Language (XML) is the obvious structure for the shared data format. XML is a flexible text format and is similar to Hypertext Markup Language (HTML) which is the format for practically all web pages. XML data is self-describing or self-defining, meaning that the structure of the data is embedded within the data, thus when the data arrives there is no need to pre-build the structure to store the data; it is dynamically understood by parsers and other tools.

The basic building block of an XML document is an element, defined by tags. Each element has a name enclosed by "less than" and 'greater than" brackets, e.g. "<" and ">". An element has a beginning and an ending tag and both use the same name. The ending tag is the same as the beginning tag, but with a forward slash ("/") at the beginning. The following is an example.

<ProjectArchitect>Joseph Green, AIA</ProjectArchitect>

The outermost element is the root element, but XML can also support nested elements, or elements nested within nested elements. This enables XML to support hierarchical structures needed for energy modeling data and results. Element names describe the content of the element, and the structure (or nesting) describes the relationship between the elements. XML's power resides in its simplicity and versatility.

Versatility is good, but it does not help us in creating a standard. What we need are a standard set of names for the elements and a standard way of organizing the data, e.g. the nesting of elements. Portability is not provided if one element is named <ProjectArchitect> another is <ProjArchitect> and another is <Architect>, when they all mean the same thing. An XML Schema is a language for constraining XML documents. A schema requires that the names be something that is identified in the schema and that the relationships between elements be consistent.

EXISTING SCHEMAS

We don't have to start from scratch to find a standard schema for transfer of simulation data. There are several schemas that have been developed for similar purposes that can be either used directly or adapted. These are described in this section of the paper.

gbXML and Derivatives

gbXML is one of the first schemas developed for energy models. It is robust and has been modified for multiple purposes. Its main purpose is to standardize the *inputs* to energy models. It does a very good job of describing the geometry, zoning and envelope components and has capabilities with regard to HVAC systems. Its principle purpose is to standardize inputs to models but it also includes a flexible results element which can be used for different result types (peak load, energy, cost, CO_2, etc.) and multiple resource types (electricity, gas, oil, etc.).

The primary derivative of gbXML is the XML structure used by the California Building Energy Code Compliance (CBECC) software. There are two versions of this software that have little in common: low-rise residential and commercial. The latter is referred to as CBECC-Com. This data structure is a direct derivative of gbXML, but extended to include more HVAC systems and mechanical equipment. The CBECC-Com XML elements use the Standard Data Dictionary for names, a list created by the California Energy Commission (and its contractors) for the purposes of the software.

The CBECC-Com data structure is messy, since there is no schema. Energy results are concatenated on the end of the input file in an XML format, but neither the input nor the output comply with the constraints of an XML schema. Since California applies weights to each hour of energy use through time dependent valued (TDV) energy, much of the output is hourly.

COMNET

COMNET is a quality assurance program for buildings energy modeling. As part of the COMNET Modeling Guidelines and Procedures originally developed in 2009, a standard XML format was developed for simulation results. The COMNET XML schema can be downloaded from the website at

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http://www.comnet.org/download-comnet-xml-schema. Several energy simulation software developers have already added the ability to generate a COMNET compliant XML file.

The COMNET standard report is a simple data structure consisting of four elements: a building summary, a list of energy efficiency measures, the results of the energy simulation and a representations report. See Figure 3.

- The building summary or project data has top-level information about the building like the name and address of the project, the floor area, number of stories, window wall ratio, etc. This data is not at a level of detail adequate to generate an energy model, but is just summary information about the project. See Figure 4.
- The energy efficiency measure list is a text description of the significant energy efficiency features that distinguish the rated or proposed building from the baseline building. This list would be entered by the modeler or taken from a database when the rated building is created from software that applies measures from a pre-established list. See Figure 5.
- The energy results report has a set of modeling results for the baseline building, the rated building and any other alternatives that are appropriate, such as rotations of the baseline building. For each, end use energy data are provided by any defined time-step, e.g. monthly, hourly or sub-hourly. See Figure 6
- The representatives report contains statements by the energy modeler, architect and others on the design team on the quality of the energy analysis, e.g. that the model and the design drawings agree with each other.

The COMNET data structure (XML schema) was developed for the specific purpose of transferring energy modeling results. Information about the model is limited to a high level summary. Energy efficiency measures are verbal descriptions that may contain little technical information or a lot, depending on how verbose and detailed oriented the design team and energy modeler is. Energy results, the main section of the COMNET report, is very detailed. The representations are flexible enough to be used for code compliance, recognition programs or incentive programs.

The names assigned to elements were developed before BEDES[1] so the element names do not comply with the BEDES standard dictionary of terms, however, there is great similarity and the COMNET schema could easily be adapted.

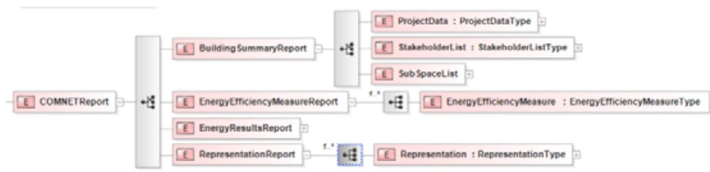

Figure 3 – COMNET Top Level Data Structure

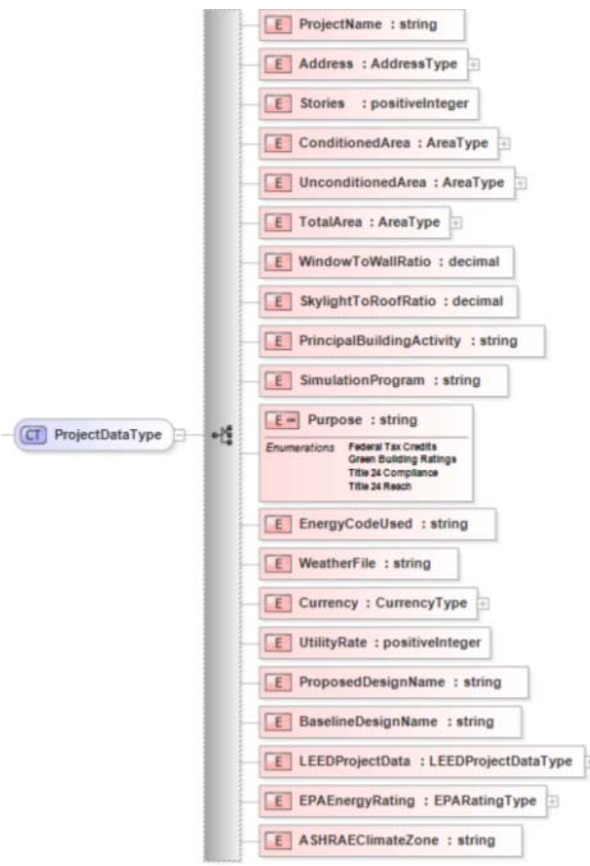

Figure 4 – COMNET Project Data

[1] The Building Energy Data Exchange Specification (BEDES, pronounced "beads") is a dictionary of terms and definitions commonly used in tools and activities that help stakeholders make energy investment decisions, track building performance, and implement energy efficient policies and programs.

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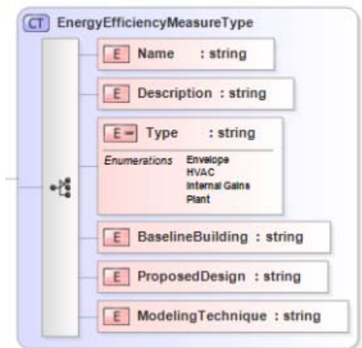

Figure 5 – COMNET Energy Efficiency Measure Data

Figure 6 – COMNET Energy Results Data

EDAPT

The EDAPT (Energy Design Assistance Program Tracker) website was developed by NREL to support energy efficiency programs operated by Xcel Energy and other program administrators. Data from software applications is shared through an XML format that is similar but simpler than the COMNET XML. The purpose of the website is to track the progress of applications through the approval process. Energy results are stored for multiple alternatives. One of the alternatives can be the baseline building. Monthly energy information is stored for each alternative along with other basic information about the building like floor area and a description of the baseline and changed conditions. The format does not accommodate hourly or sub-hourly data.

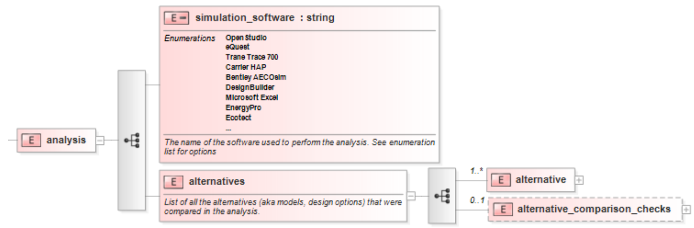

Figure 7 – EDAPT Top Level Data

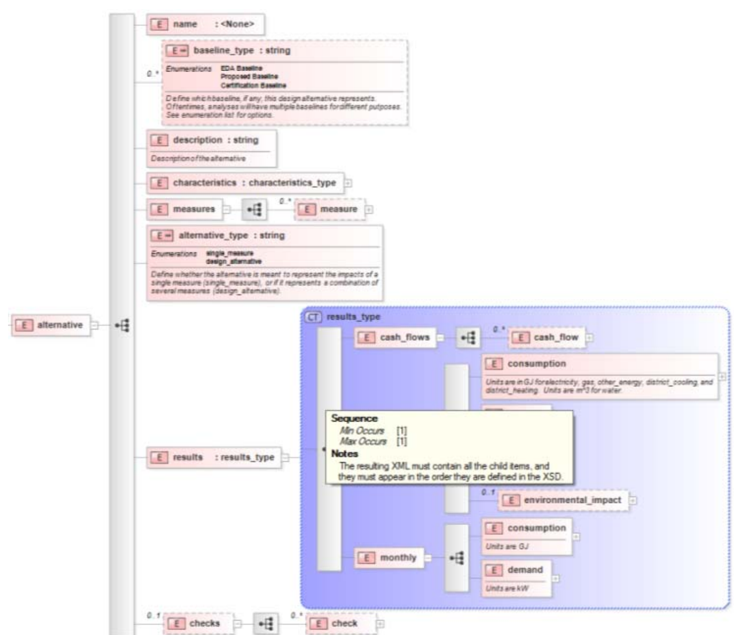

Figure 8 – EDAPT Alternative Data

BuildingSync®

BuildingSync is an XML schema designed to standardize building energy audit data. ASHRAE Standard 211P[2] recommends the use of BuildingSync in an informative appendix. The schema was developed by NREL and is in its second release. The most current

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[2] ASHRAE Standard 211 is a proposed standard for energy audits. It takes information currently published in the *Procedures for Commercial Building Energy Audits*, Second Edition, 2011 and translates it into standards language. The standard is expected to be released for public review at mid-year 2016.

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version is 2.0, released late in 2015. BuildingSync is not intended to accommodate energy simulation data, but the results section is flexible enough to work. BuildingSync was developed after BEDES and uses this standard dictionary of terms.

Of all the XML schemas reviewed in this paper, BuildingSync is by far the most robust. At the root of the schema is a collection of audits. Each building can have multiple audits. For each audit, information is organized in six categories: Sites, Systems, Schedules, Measures, Report and Contacts. See Figure 9.

- **Sites**. The sites information contains detailed information about the physical characteristics of the building, the occupancy classification, eGrid region, weather data used in the analysis and more. This data is not structured in a way for transfer to an energy input file for modeling, but rather is more akin to the COMNET project data. Floor area can be broken down into any number of sub spaces. Most of the physical information is what can be observed by the auditor.
- **Systems**. The systems information is not limited to HVAC and lighting systems, it also includes cooling, laundry, walls, roofs, floors, and fenestration. For fenestration, information can be recorded on the type of glass; whether the air gaps have air, argon or krypton; the type of frame and much more.
- **Schedules**. The BuildingSync data format can store information on any number of building operation schedules, e.g. lighting, fans, people, etc.
- **Measures**. This is a list of all the things that the auditor recommends to improve the energy and water performance of the building. Each measure has a name, a useful life, a cost, and an analysis of energy savings.
- **Report**. This is the section is where energy modeling results would be stored. Multiple scenarios may be nested within the report structure. One scenario could represent the baseline building while another could represent the rated building. The structure of the scenario data type is quite robust and can accommodate energy results broken down by end uses and by any time step[3].

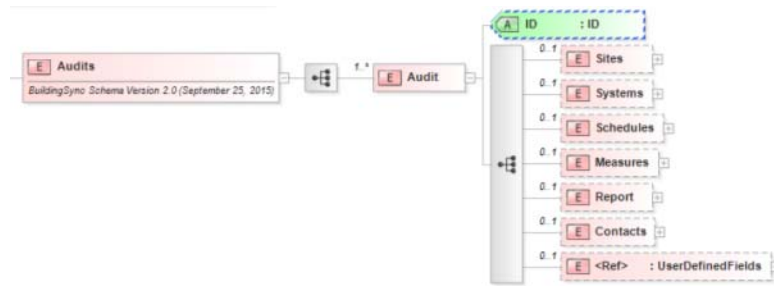

Figure 9 – BuildingSync Top Level Organization

Comparing the Schemas

Table 1 is a summary comparison of the XML schemas reviewed and described above.

3 The hourly or sub-hourly data is in what is called sub-metered end-uses at any time step.

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Table 1 – Summary Comparison of Existing XML Schemas

Consideration	*gbXML*	*CBECC-Com*	*COMNET*	*EDAPT*	*BuildingSync*
An XML schema exists to constrain input	Yes	No	Yes	Yes	Yes
BEDES Compliant	No	No	No	No	Yes
Accommodates energy results at different time steps	Yes	n. a.	Yes	No	Yes
Designed for existing building audits	No	No	No	No	Yes
Robust and flexible	Yes	n. a.	Medium	Low	High
Designed specifically to capture energy modeling results	No	No	Yes	Yes	No
Already implemented in software	Yes	Yes	Yes	Yes	Yes
Contains the level of detail needed for input to an energy simulation model	Yes	Yes (used for CBECC software)	No	No	Yes (but just for DOE Asset Score)

gbXML and its derivative CBECC are intended as a format for modeling inputs, not outputs. CBECC-Com stores information in an XML format, but there is no schema to constrain inputs. New elements can be added and element names can be changed by the software developers. CBECC-Com software also stores simulation results in an XML format, but again there is no schema or structure that program administrators can use to accurately parse the simulation results. Without a schema, it is really not in a form that can be used as a standard.

The COMNET schema was developed for the explicit purpose of sharing modeling data and for this reason it is compact and focused on this sole purpose. A schema has been developed to constrain and order the data, but because of its vintage, the element names are not consistent with either the Standard Data Dictionary adopted by California or the BEDES dictionary maintained by LBNL. COMNET results for various pre-determined end-uses can be stored at any time step of the simulation. The COMNET schema has been tested and implemented in several software applications and has been used by at least one program administrator. COMNET has also developed a portal through which data is transferred and within which a basic level of data checking is performed.

EDAPT was developed for a similar purpose as COMNET, but is much simpler. Its format can be output from OpenStudio. It works well for its intended purpose, which is to support a website that tracks applications for incentives.

BuildingSync is a large, robust, and complex XML schema which was developed for another purpose, to support energy audits of existing buildings. It is compliant with the BEDES dictionary of terms and the schema does a good job of constraining input. Very few of the elements are mandatory, so it would be reasonably simple to adapt it for the purposes of transferring modeling results. Unlike gbXML and CBECC, it does not have the hierarchical structure and detail needed to generate energy models. It does support input to the DOE Asset Score tool, which is a simulation tool, but one that receives simplified data. BuildingSync also supports information on ENERGY STAR, LEED and other programs, e.g. whether or not the audited building meets the requirements of these programs and the level of recognition received. .

CONCLUSION

There are many benefits to a standard electronic format for sharing energy simulation data. Modelers are less burdened with the task of filling out forms and transferring information. Program administrators have more confidence that the results that make their way to their databases at least agree with the energy models and no errors were made in data transfer.

A widely used and acceptable standard will require input from all stakeholders. Software developers will need to make the investment to add features to their software to produce output in this common format. They need to participate in the process to assure that the information required by the schema can be automatically produced by their software. Program administrators need to participate in the process to

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make sure that the information they need is included in the schema. Energy modelers need to understand the standard exchange format and use it.

An organization or owner for the schema needs to be established and its role would be to vet changes to the schema and manage updates in an orderly manner, preferably in a way that is backwardly compatible with previous versions of the schema.

This entity can be a separate organization established for the sole purpose of developing and maintaining the schema, or it can be housed within an existing organization, probably a 501(c)3 non-profit. The governing body should have representation from software developers, program administrators and energy modelers. A formal process should be in place to release updates.

The managing organization needs the flexibility to quickly correct errors or bugs, which means that the XML standard would likely work best if it were NOT an ANSI consensus document.

The tipping point will be when one of the large energy programs (like ENERGY STAR or LEED) begins to require the use of the standard XML schema. Once this happens, and one or more of the dominant software developers implement the standard XML, progress will be made.

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