BuildingSync® in Action: Example Implementations

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ABSTRACT

Interoperability is a particular challenge in building energy auditing, in which tools and data requirements may vary widely depending upon locale or intended use of the audit result. There are, however, many reasons to represent the data in a common format. BuildingSync® is such an effort to develop a standardized language to flexibly represent and exchange building energy auditing data between software tools. The schema has been developed with extensive collaboration between the United States Department of Energy (DOE) and industry experts. BuildingSync facilitates a consistent history of energy audit data across the life of a building or a group of buildings, and thus enables lower costs and higher energy performance results. It also facilitates easier aggregation and analysis of audits conducted by different companies using different software. This paper presents two examples of building energy analysis efforts that are utilizing BuildingSync – (1) BayREN Integrated Commercial Retrofits (BRICR), a utility custom incentive program at the Bay Area Regional Energy Network (BayREN) that uses BuildingSync to exchange building data, and (2) New York City's ordinance on benchmarking and auditing data. These efforts utilize BuildingSync in conjunction with other DOE-sponsored tools, such as the Asset Score Reporting Platform, SEED Platform, and OpenStudio. Using the lessons learned from these efforts, the paper also makes recommendations for applicability to future projects that may benefit from BuildingSync.

Introduction

BuildingSync is a common schema for commercial building energy audit data that can be utilized by different software and databases involved in the energy audit process. It allows data to be more easily aggregated, compared, and exchanged between different databases and software tools. The ability to exchange data easier streamlines the energy audit process, improving the value of the data, minimizing duplication of effort for subsequent audits, and facilitating achievement of greater energy efficiency. The schema was built using the standard terminology defined in the Building Energy Data Exchange Specification (BEDES) dictionary (BEDES 2018). Existing data formats and guidance about how to conduct energy audits were incorporated whenever possible, making it easier to reconcile and map data from existing databases to BuildingSync (BuildingSync 2018). Figure 1 demonstrates how BuildingSync, built on the BEDES data dictionary, facilitates interoperability between different databases and software.

BuildingSync was developed to address the lack of an industry-standard collection format for energy audit data. Standardizing energy audit data can help energy auditors, software providers, building owners, utilities, and other entities by maximizing the value that can be obtained from each set of data - value obtained through collaboration, comparison, and reuse (CBEI 2016, Kelsey 2018).
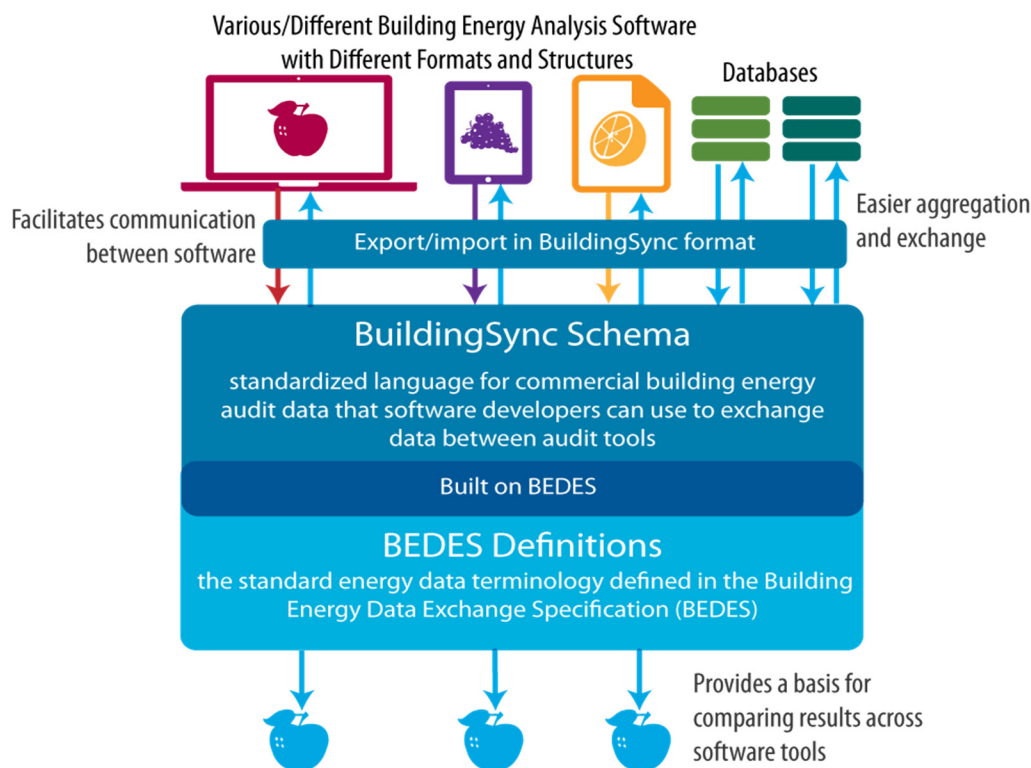
Figure 1. Visual representation of interoperability with BuildingSync. *Source*: www.buildingsync.net.

Why was BuildingSync Developed?

Commercial building energy audits are becoming more prevalent; however, the processes auditors go through to collect and exchange data have not changed substantially. There are several methods for collecting data during an energy audit that typically include a mixture of clipboards (pen and paper), spreadsheets, photographs, and personal communications with building operators/owners. Once these data are collected, the auditor completes an analysis, and the results become a report to the person requesting the audit. Currently, the energy audit industry lacks a common data format for the collected data and subsequent analyses on the data (Taylor 2016). Since the data collection differs widely between energy auditors, as do the outputs from various energy audit software tools, it is difficult to aggregate the data collected by different auditors, or to make comparisons between buildings that have been audited by different auditors using different software (BuildingSync 2018). Most energy service providers develop their own custom tools for audit data collection and analysis. Some of the common commercial tools used for audit data collection and analysis include simuwatt (simuwatt 2018) and Facility Energy Decision System (FEDS 2018). Not only are commercial building energy audits becoming increasingly common, but in some cases, they are becoming required, such as in the federal sector and in various cities, including New York City and San Francisco. The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) has developed a standard for commercial building energy audits; however, this process would be complicated by the lack of a standard data specification for information collected and reported, as well as the lack of consistency in data formats across audit software applications (BuildingSync 2018). To

mitigate this complication, BSR/ASHRAE/ACCA Standard 211P, Standard for Commercial Building Energy Audits (ASHRAE 2018), recommends and encourages submissions in BuildingSync format.

During the development of BuildingSync, several other existing building information exchange formats were investigated to ensure that BuildingSync was not a duplicate effort. It was important to understand how gbXML (gbXML 2018), HPXML (HPXML 2018), Green Button (Green Button 2018), CBECC-Com/SSD (CBECC-Com 2016), and EDAPT (EDAPT 2018) could be compatible formats with, and not a competitor to, BuildingSync (Eley 2016 - Table 1). BuildingSync was developed to aid in the exchange of building information as related to building energy audits; however, this does not mitigate the need of other industry standard formats.

What Can BuildingSync Do?

The BuildingSync schema provides for varying level of detail and flexibility in the representation of audit-related information, which opens it up to a large number of applications and workflows. Figure 2 below shows the highest level of BuildingSync hierarchy, and some of the key components have been explained in the bullets that follow.
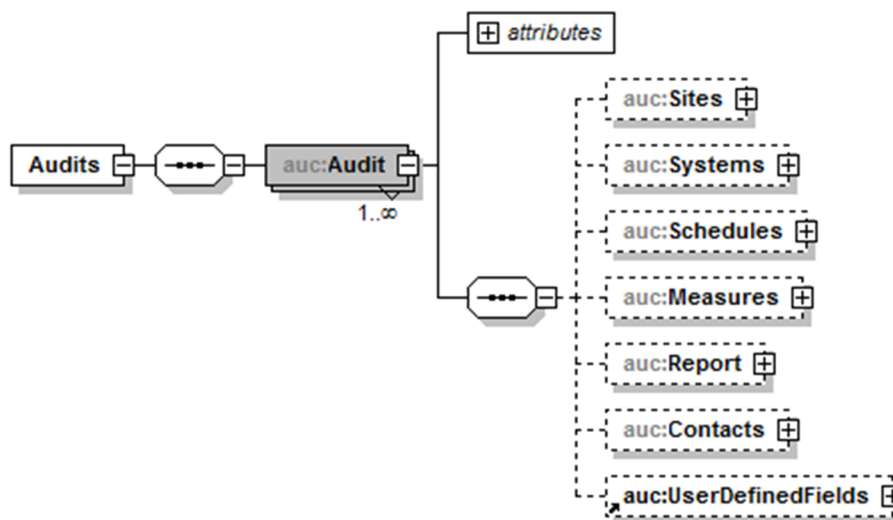

Figure 2: Highest levels of BuildingSync hierarchy. *Source*: https://github.com/BuildingSync/schema/blob/develop/BuildingSync.xsd.

- Sites: A site, as defined by BEDES, is the land on which the premises are built and can comprise one or more "facilities." Hence, the schema can accommodate several scenarios of reporting, whether its for a single building on a lot, multiple buildings on a lot, or a small portion of a building on a lot.
- Systems: The "Systems" category of BuildingSync includes attributes for HVAC systems, building envelope systems, lighting systems, etc. Each of these categories has

several attributes which provide a great level of flexibility for the reporting of ASHRAE Level 1, 2, or 3 audit data.

- Measures: The "Measures" section of the schema defines the representation of various interventions into the systems of the building(s). Typically, these interventions are intended to save energy by changing out a system or modifying the behavior of a system, so the schema allows for flexible connection of a modification (e.g., "Replace a boiler") to the affected building or building subset (e.g., "The north wing of building A").
- Report: "Report" refers to an audit report and allows for reporting of multiple scenarios of analysis, including benchmarking data through Portfolio Manager, time series utility data, or Building Energy Asset Score (Asset Score 2018) data. Energy efficiency measures defined within the "Measures" element can be grouped together and combined within a "Package of Measures" under the "Report" section. The auditor has the flexibility to specify savings by each measure or for a package of measures.

The schema is comprehensive and flexible, and it facilitates several new applications for the use of audit data, including:

- Data Management of Historical Audits: Usage of the BuildingSync schema facilitates a consistent history of energy audit data across the life of a building or a group of buildings, and thus enables lower costs and higher energy performance results. The schema is sufficiently flexible to allow users to choose a workflow that works best for their purposes, but it keeps data in a compatible format.
- Data Exchange and Interoperability: BuildingSync provides a common schema for energy audit data that can be utilized by a variety of software and databases. Data can be transferred between a variety of software tools. This streamlines the energy audit process and leads to new opportunities.
- Large-Scale Data Analysis and Decision Making: Using the schema ensures that data collected for a single building over time is consistent and comparable and that data from different buildings can be easily aggregated and compared for large-scale analysis. By delivering energy audit data in a common format, energy auditors can make it easier for their customers to use the data to make decisions.

The BuildingSync schema has been developed in cooperation with subject matter experts to facilitate these benefits and more. Before discussing uses of the schema, it is important to highlight the fact that BuildingSync is only a schema. It is not a software tool in the traditional sense, and, while it defines a format for communication between software tools, it leaves the implementation details entirely to those tools.

BuildingSync Implementation for Building Energy Modeling

Building energy audit data in BuildingSync format can provide value in several ways, one of which involves the creation of building energy models. The first example implementation of BuildingSync discussed in this paper takes data from city building records and creates building energy models to run simulations.

The Bay Area Regional Network's (BayREN's) Integrated Commercial Retrofits project (BRICR) originated from BayREN's recognition that the small and medium commercial buildings (SMB) had been difficult to reach in terms of energy efficiency (EE) opportunities. As

part of the Association of Bay Area Governments (ABAG), BayREN, an organization of nine San Francisco Bay Area counties, has developed and implemented several successful local energy savings programs and wanted to ensure that this progress extended to the SMB sector.

In addition to the overarching goal of helping local SMBs to save energy, BayREN agreed on some specific goals for the BRICR effort:

- Perform city-scale building energy modeling to target energy efficiency potential for SMBs in the BayREN territory.
- Increase SMB sector's access to deeper energy efficiency savings through comprehensive retrofits – beyond deemed measures of existing incentive programs.
- Streamline finance processes, enabling third-party lenders to finance EE projects based on a standardized ICP Building Button data format.
- Measure realized energy savings via OpenEEmeter (OpenEEmeter 2018) for enhanced evaluation, measurement, and verification (EM&V).
- Automate the workflow and create user interfaces whenever practical to reduce the burden on both auditors and EE program staff.

Phases of BRICR Project

The BRICR project consists of three phases - Phase 0, Phase 1, and Phase 2. BRICR is currently in Phase 0 and will likely be investigating Phase 1 at the time of this paper's publication. To demonstrate the progression involved with each phase, Table 1 lists the corresponding inputs, outputs, and building retrofit project activities.

Table 1. BRICR inputs, outputs, and building retrofit project activities by project phase

	Phase 0 - Screening	Phase 1 - Refinement	Phase 2 - Implementation
Inputs	Automated: Public records	Manual: Updated site data Updated measures Past measure costs	Manual: Final site data Final measures Final costs
Outputs	Potential measures Potential savings	Savings estimates	Final modeled savings
Building retrofit project activities	Enroll SMBs	Baseline existing building Prepare proposal Present proposal	Installation Post-installation EM&V (OEE)

Phase 0 (Current) Workflow

BRICR's current Phase 0 workflow uses BuildingSync to transfer information between several tools to create a new analysis framework for multi-phase energy modeling of commercial buildings. LBNL's CBES (CBES 2018) and CityBES (CityBES 2018) tools aggregate building data from public records (e.g., building area, zoning, or renovation date from tax assessor or building permits) which is exported to BuildingSync and stored in USDOE's SEED Platform (SEED 2018). NREL's OpenStudio platform (OpenStudio 2018) is leveraged by new open-source software to convert BuildingSync files to multiple energy simulations, one simulation for

the baseline and additional simulations for each package of measures considered. BuildingSync is used to transfer simulation outputs of predicted energy savings for each measure package back to SEED. PNNL's Audit Template tool (Asset Score 2018) can be used to edit BuildingSync files, adding additional information collected by telephone interviews or on-site audits, which can then be re-simulated using OpenStudio.

The first portion of the Phase 0 workflow involves aggregating public building records, converting them to BuildingSync format, and storing them in SEED. LBNL's CBES and CityBES tools have aggregated records for the City of San Francisco into a GeoJSON format. As part of the BRICR project, NREL and LBNL have developed software to convert the GeoJSON records into BuildingSync format. PNNL's Audit Template tool (AT) can also create or modify BuildingSync files to be used in this workflow. Once the building data is stored BuildingSync format, a user uploads them to a SEED instance. Currently there is a dedicated SEED instance for storing BRICR data. In the future, however, the same SEED instance could support benchmarking, auditing, BRICR, and similar use cases.

When new BuildingSync files are uploaded to SEED, BRICR software written by NREL and LBNL translates each BuildingSync file into multiple OpenStudio files (one for the baseline and one for each ECM). After all the OpenStudio simulations finish, the results are stored back into BuildingSync format and sent back to SEED. The code that performs these actions is open source.

As part of the BRICR project, NREL and LBNL simulated real EE measures on the San Francisco buildings imported from the CBES/CityBES data. For quality assurance, the team calibrated baseline (no ECM) outputs against publicly disclosed building energy data. The team examined the results, presented them to BayREN, and provided value on the "front end" to BayREN's and the City of San Francisco's understanding of the SMB stock and its EE opportunities.

Applicability to Other Efforts

Several components of the BRICR workflow have the potential to provide value to other EE analysis efforts. The publicly available BRICR code repository[1] allows translation of BuildingSync files to multiple OpenStudio "OSW" files. This step is significant in that it offers a path from audit or other building information to building energy simulation. The code also translates the OpenStudio results back into BuildingSync format. Before and after simulation, the BuildingSync information can be stored and accessed through SEED.

BuildingSync Implementation for New York City

BuildingSync data can also provide value to municipalities that collect large amounts of energy audit data as part of their mandatory audits. The second example implementation discusses how New York City (NYC) leverages the BuildingSync format to streamline their collection process and increase the utility of their audit data.

NYC's Local Law 87 (LL87) mandates periodic energy audits as a part of the Greener Greater Buildings Plan (GBEE 2018a). A large amount of audit data has been collected during this process using the LL87 Energy Audit Data Collection Tool (GBEE 2018b), which is a spreadsheet-based tool for audit data reporting. Use of spreadsheet tools for data reporting,

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[1] The publicly available BRICR code repository is located at: https://github.com/NREL/bricr.

though less complicated, can be prone to errors and also does not facilitate large scale data analysis. NYC has now adopted the AT tool to improve its audit data reporting process and facilitate better data management and data exchange. Building data entered in AT tool could also be translated to an Asset Score (Asset Score 2018) model, facilitating further analysis through energy simulation.

Introduction to the Asset Score Tool

The Asset Score tool has been developed by Pacific Northwest National Laboratory (PNNL) for the United States Department of Energy (USDOE). It is a web-based tool which provides a simplified user workflow for a user to specify the as-designed characteristics of a building, including its geometric configuration, envelope, mechanical, and lighting systems (Wang et al. 2015). The Asset Score tool develops a whole-building energy model using EnergyPlus (EnergyPlus 2018) and OpenStudio and scores a building based on its modeled energy use intensity (EUI) (Wang et al. 2016). The tool also runs an optimization of the user-defined building to identify cost effective upgrade opportunities. These capabilities allow a user, with minimal investment, to analyze a large number of buildings and identify the buildings with the highest potential for energy savings and potential retrofit opportunities. Based on the building characteristics (such as the envelope construction, lighting systems, HVAC systems, etc.) specified by the user, the Asset Score tool develops a whole-building energy model and scores the building using the simulated source EUI. It also runs a series of optimizations to identify cost effective upgrade opportunities to give the building a "potential score" based on the EUI of the improved building. Figure 3 shows an Asset Score result, which identifies the "current score" and "potential score" for the building.
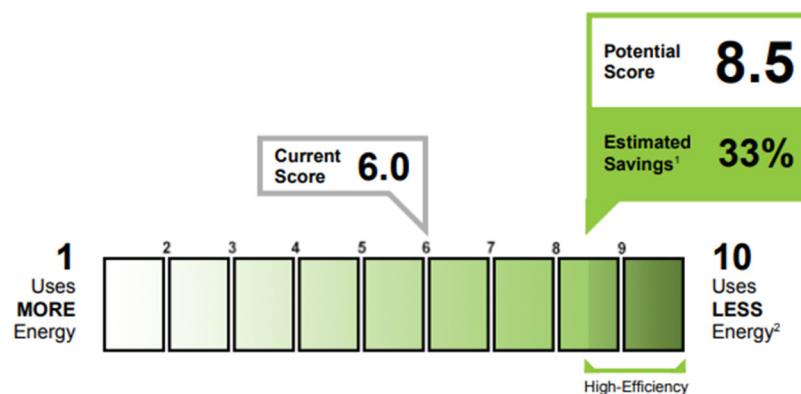

Figure 3. Asset Score result output, showing current score and potential score. *Source*: https://buildingenergyscore.energy.gov/.

The AT capability in the Asset Score tool allows an auditor to document a building's ASHRAE Level 2 audit minimum reporting requirements, in accordance with Standard 211P. Standard 211P, along with defining the procedures required to perform Energy Audits Levels 1, 2, and 3, also establishes the minimum reporting requirements for the results of energy audits. The AT tool has been developed as an additional capability within the Asset Score tool to allow auditors to report audit data for programs or jurisdictions with audit ordinances. The program

administrators have access to a "City Dashboard," through which they can monitor submissions, verify the reported data, and download the reported data in a standard CSV format. Auditors using the AT are provided with a mobile-friendly interface, which, through its robust validations and structure, performs quality checks on the data submitted, verifies the minimum reporting requirements, and allows them to submit the audit data and additional information (like images, auditor's qualification certificate, etc.) through the online submission interface.

This standard interface for collecting and reporting audit data also facilitates data storage and exchange via BuildingSync. A BuildingSync import and export function has been developed for the AT tool; this function allows audits to be exported via BuildingSync for further analysis in other audit tools. Data could also be imported into DOE's SEED platform, through which cities and program administrators could utilize it for various purposes, such as informing future programs or monitoring the effectiveness of previous programs. In addition, an AT building could be converted to an Asset Score building, which would a used to generate an energy model with minimal effort.

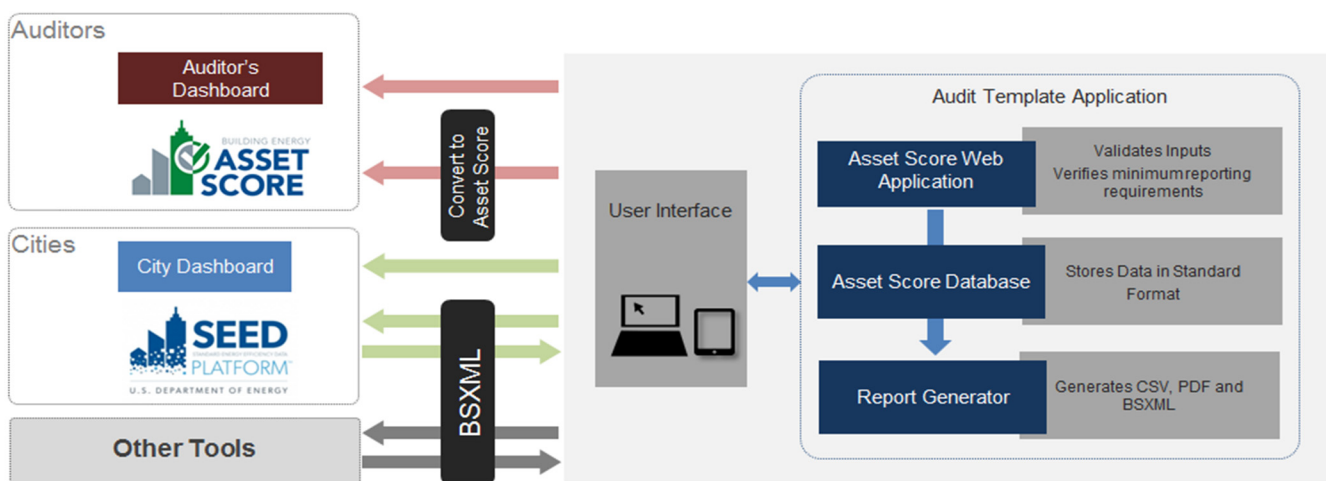Figure 4 shows the workflow that connects Asset Score and SEED with the AT tool.

Figure 4: Audit Template workflow. *Source*: Supriya Goel, PNNL.

Implementation of LL87 in the Audit Template

New York City's Local Law 87 (LL87) requires buildings over 50,000 ft^2 to undergo periodic energy audit and retro-commissioning, as part of the Greener, Greater Buildings Plan (GGBP). Buildings are required to undergo an audit every ten years and report information related to the existing equipment inventory in the building, the energy use by end use, energy savings measures as identified by the auditor, along with the measure costs and estimated savings.

Reporting must include all measures that would reduce the energy use and/or cost of operating the building (NYC 2009). For each measure, the auditor is required to estimate the associated annual energy savings, the cost of implementation, and the simple payback. Along with information about energy savings opportunities, the auditor is also required to report the building's benchmarking output consistent with the United States Environmental Protection Administration (EPA) Portfolio Manager tool (ESPM 2017). Additionally, LL87 requires reporting of the break-down of energy usage and predicted energy savings by system after

implementation of the proposed measures. Auditors are required to carry out and report on a general assessment of how the major energy-consuming equipment and systems used within tenant spaces impact the energy consumption of the base building systems, based on a representative sample of spaces. This audit data has been reported to the city using the LL87 Energy Efficiency Report (EER). The City has post-processed the data to develop a CSV file. This data is then analyzed by the City to identify the efficiency of the existing buildings, and it also informs the incentive programs developed by the city and utilities.

LL87 has been in effect since 2009, and the spreadsheet storage method has limited the way in which the data can be interacted with, analyzed, or queried. Having access to this data in a standardized format like BuildingSync would allow the City to do large-scale analysis of the building data in a structured manner and would help inform the development of policies and incentive programs based on actual building data. The capability to write out BuildingSync files from the AT tool will now allow the LL87 data to be transferred to other tools and databases for access and further analysis. There is also a parallel effort underway to write out historic LL87 data from the previous reporting years into the BuildingSync format. This data could then be read into the Asset Score tool through the AT interface for further analysis. The import and export capability facilitated through BuildingSync will give city and program administrators access to the building stock analytics available in the Asset Score tool, as well as any other tool that utilizes the BuildingSync format.

Future Work

BuildingSync, in its current state, is a viable standard for exchanging data; however, there still needs to be more done in order to make BuildingSync more compatible with future use cases. In the near future several additions and update will be made to BuildingSync including:

- Robustness: BuildingSync is a very large schema with thousands of elements. The schema will be updated to ensure that the elements are consistently defined. This also includes an inspectable mapping between BuildingSync elements and BEDES definitions.
- Multi-Tenant Support: The BRICR project exposed the need to be able to define tenant owners within BuildingSync.
- Use Case Selection Tool: BuildingSync is a collection of thousands of elements and not all the elements are needed for all the use cases of BuildingSync. The Use Case Selection Tool is an online tool that allows a user to upload a BuildingSync file to determine if the file is applicable to the selected use case.

There are several other mid- and long-term desired BuildingSync features, including the ability to have a related JSON Schema, which would allow more modern web-based development, breaking up the schema into smaller, reusable portions, tighter integration with other existing standards, and better integration into building energy modeling workflows.

Conclusions

The BuildingSync schema was developed to aid in the exchange of building information related to commercial building energy audits. The schema has the potential for streamlining audit workflows by allowing automated (computer-to-computer) exchange of information. The BuildingSync schema has been developed with extensive input from a large number of

stakeholders, and software tools are starting to make investments to add features to their software to produce output in this common format.

This paper discussed how BuildingSync was being implemented in various projects, such as BRICR and the AT tool. If proven successful, BuildingSync will help facilitate development of better incentive and software programs based on easier exchange of actual building data. BuildingSync is being continuously vetted and updated to include requirements from various programs that have started using it and has a formal process in place to make revisions and release updates to the schema. As more software programs and tools start adopting BuildingSync, the number of applications that can connect via this exchange medium will continue to grow.

Furthermore, if there exists a standard data format for commercial building energy audits, then the ability for aggregated analyses become more easily accessible. BuildingSync's feature of tracking proposed and installed measures would allow for a quick sector evaluation of energy auditing impact by measure types and cost effectiveness, with both a geographic and temporal lens.

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