Energy Consumption Data Testimony
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A proposed measurement approach and computing system needed to accurately predict energy consumption (and other attributes) — essential to the development of performance-based planning, design, standards and commissioning

Indirect Simulation to Direct Actual Data Measurement System

Direct measurement of actual whole-building (tier one) data can be used to accurately predict energy consumption (or other attributes) in most past or future buildings, only if accompanied with **indirect simulation of deeper (building system tiers two and three)** cause and effect relationships. In other words, a deeper simulation of a small control sampling of the CBECS[i] buildings will result in a much **higher accuracy when predicting the energy consumption for a second sampling CBECS buildings.**

This Indirect (Simulation) to Direct (Actual Data) Measurement System is referred to as the ***IDM System***. The IDM System approach proposed to accomplish this is the same that is being employed through DHS/NIBS Performance-based Building Design for Envelopes (HPBDE) Program — the OPR[ii], (Owner Project Requirements) Tool. Under this program, the capital development and life-cycle costs, and other metrics, are simulated (predicted) based on many multivariable and interactive cause and effect relationships. Among the several validation processes that help insure the prediction accuracy is the direct measurement of actual existing buildings. The OPR's simulated data built up from many parameters are rolled up to a whole-building equivalent and then compared to the actual whole-building metrics — the results of which are used to validate and calibrate the OPR tool.

> **PRINCIPLE: A modeling system that can accurately predict the *actual* energy consumption of past, completed buildings will be able to predict the baseline energy consumption for *future* buildings.**

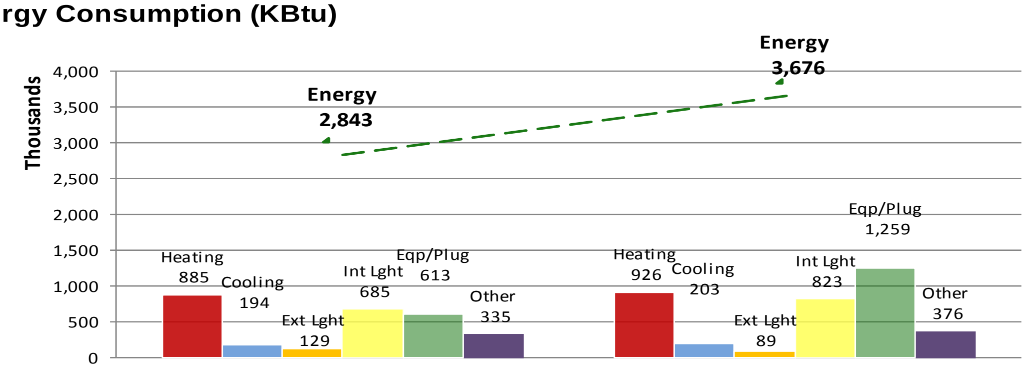
There are several such cause and effect instances that cause the unacceptably high RSE (Relative Standard of Error) in CBECS. Two significant ones are addressed and illustrated here. The first relates to the interior Energy Use Intensity, and the second relates to Building Geometry and Envelope Material Composition. A third cause and effect relationship that will be increasingly important is the performance standard by which building was designed (i.e. ASHRAE 90.1, 2004, 2007, 2010, ASHRAE 189, Zero Net Energy, etc.). This IDM System accommodates all these.

Energy Use Intensity Variation

CBECS collects data at the whole-building level (referred to as Tier 1) — according to principle building activity (PBA). There are 14 such classifications, such as “Office” and “Health Care – Outpatient.” The problem is that the Energy Use Intensity (EUI) can vary dramatically based on the Tier 2 and possibly even the Tier 3 space uses. The below illustration shows two such facilities that would both fall into the “Health Care – Outpatient” PBA. Both are the same building configuration, material composition, and climate zone. But Scenario 1 is a group of Physician Practices, while Scenario 2 is an Ambulatory Surgical and Diagnostic Imaging Center. The Energy Consumption profile for each, as submitted to the RPM Modeling System, is shown by this graphic.

Scenario ID	Control Scenario	Comparative Scenario
	Sc 1 - Physician Practices	Sc 2 - ASC & Diag Med

Annual Energy Consumption (KBtu)



Total Mean Energy (Kbtu)	2,843,000	95 KBtu/SF	3,676,000	123 KBtu/SF

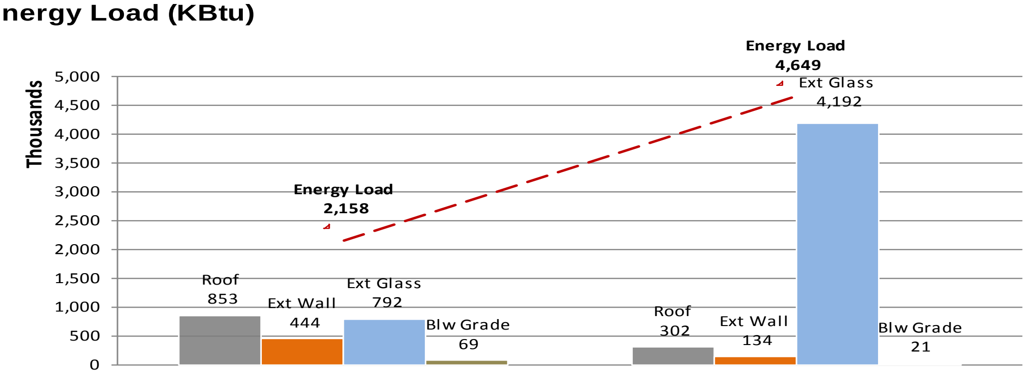
As you can see there is a 30% difference in energy consumption from the Physician Practices to the ASC and Diagnostic Imaging Center, the vast majority of which is in the Equipment/Plug Loads. This high variation is not resolved in the CBECS data outputs, but it is through the IDM System. Mixed Use projects are especially in need of this approach to predict consumption.

Envelope & Material Composition Variation

As a second illustration, the correlation of energy consumption to the Window to Wall Ratio (WWR), and Floor plate to Floor-Wall Ratio (FWR) shows dramatic variations that are not accounted for in CBECS. In the following there are two office buildings with identical interior Energy Use Intensities and Net Building Areas, and they are in the same climate zone. Scenario 1 is a 2-story with ½ of the lower level below grade, with a .20 WWR and .40 FWR. Scenario 2 is a 6-story Glass (.90 WWR) building with a .70 FWR.

Scenario ID	Control Scenario	Comparative Scenario
	Sc 3 - 2 Story Office	Sc 4 - 6 Story Office - Glass

Envelope Energy Load (KBtu)

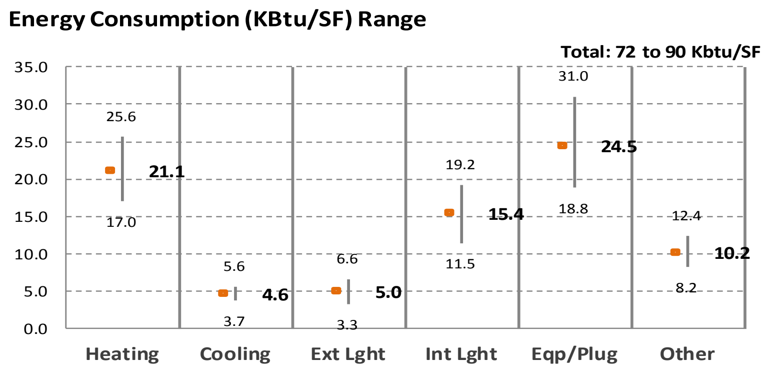


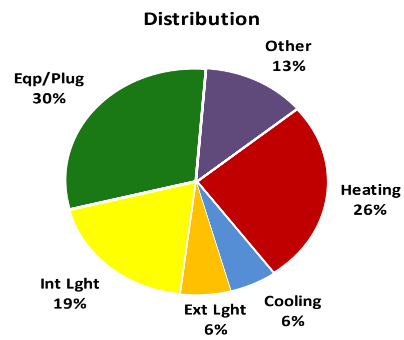
Total Mean Energy (Kbtu)	2,158,000	23 KBtu/SF	4,649,000	46 KBtu/SF

By segregating the envelope demands through the IDM System the result is that the envelop demand on Scenario 2 is 100% greater than that in Scenario 2. While the CBECS tracks number of floors, and also building area, it does not resolve these more important ratios relating to the building envelope.

Acceptable and Useful Variation

The above illustrations show the mean values for energy consumption between scenarios[iii]. There is, however, a need to accurately predict the variation that will still remain. As a statistical principle — within any particular system, a variation range of +/- 20% or more — when aggregated and rolled up to the whole-building level — will yield an overall (whole-building) variation range that is substantially less. The initial stages of data collection and analysis will aggregate to the +/- 12% neighborhood, as reflected in the figure below. As continued data analysis and parametric correlations progress, and as the sampling size of the deeper data analysis is increased, the accuracy of these whole-building predictions should fall below +/-10%. This is compared to the +/- 50% or more in the current CBECS data.



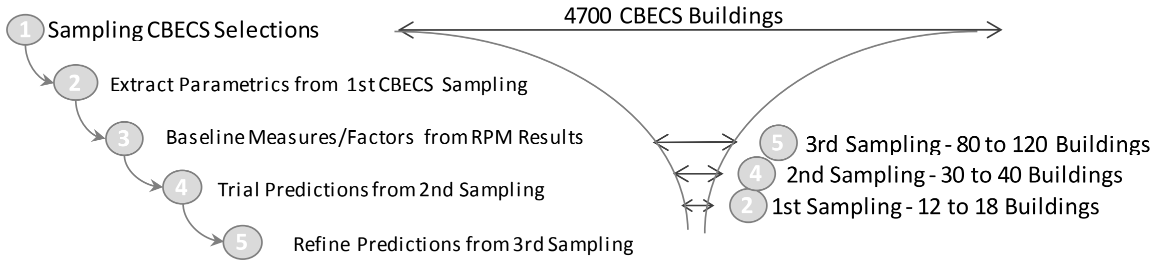


Future buildings may be sub-metered or otherwise measured in a way to more directly measure energy consumption by space function and systems. This is not the case with the CBECS data. As such an indirect measurement approach will be needed — one that then can be compared and validated at the whole-building level.

> *"Measure everything which is measurable and reduce the things which will not admit to direct measurement to indirect measurement."* ~ **Galileo**

Process for Accurately Predicting Existing and Future Building Energy

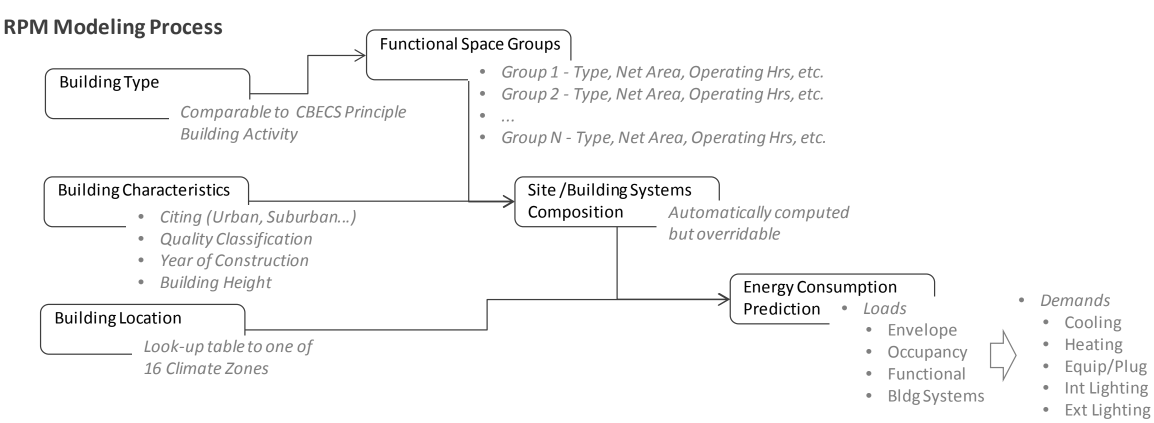
Per the above stated principle: The process and technology that will accurately predict the energy consumption of existing buildings, will also predict the energy consumption baselines of future buildings. Through a subset of actual distinct buildings in the CBECS data set, together with the IDM System technology, a process for mining and deeper data analysis is proposed here. The process is described in the below graphic.



Mining CBECS Data in RPM Modeling System

1. Select 12 to 18 actual buildings (at least 2 each from four or five CBECS PBA groups) that appear to be close-to-the-mean energy performers, and from climate zones 2, 3, 4 and 5.
2. From these buildings, the climate and building characteristic/composition parametrics (see below) are extracted that will be submitted to the design version of the RPM Modeling Tool.
3. The IDM System will provide the initial mean, low and high range predictions of energy consumption, which is then compared to the actual values from the building samplings. An iterative calibration process ensues that involves adjusting unit energy load values in the tool's database, until a relatively tight variation is achieved. If this is not achieved, then either the building characteristic parameters and correlations need to be adjusted. It could be that some of the selected buildings are just poor samples (outside of the desired statistical variation). This will also involve a study and revisions to how and what building characteristic and correlation factors are applied.
4. This process is then repeated with the 2nd sampling of buildings. In this case, however, the actual energy consumption is withheld, pending the IDM System trial predictions. The expectation is that variation accuracy is improved.
5. Finally, the IDM System and data content can be firmed up, and a web-application developed. As part of the testing of the IDM System, a 3rd sampling of buildings will be modeled and the results compared to the actual consumption. Further calibration and variation would be refined.

Based on a combination of prescriptive design approaches, data collection, and specialist predictions; the IDM System tool user interface (UI) process flows according to the following graphic.



Conclusion

If individual selected project data can be mined to deeper levels, the CBECS data can still serve as a valuable resource that is vital to employing measurement-driven improvement and innovation in energy consumption reduction—especially for America's existing building stock. If not, another existing or new source of survey data will be needed. In either case, the next step will be a deeper and more granular analysis of a small subset the data, with the proper use of process and technology to establish strong correlations between energy consumption and building characteristics/compositions; especially the functional space EUI. Such a process and technology exists through the Indirect Simulation to Direct Actual Data Measurement (IDM) System.

Once the means are in place to more accurately measure and predict cause and effect correlations to energy consumption, then the innovation needed to drive cost-effective energy reduction solutions will follow. The same principle applies to the other performance-based building attributes as well.

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[i] The Commercial Building Energy Consumption Survey by the DOE Energy Information Administration.

[ii] Performance Building Systems' Catalyst [2] is the RPM Modeling Technology Used here for illustration purposes.

[iii] These illustrations include only placeholder values for energy consumption and correlation factors to building characteristics. Establishing, validating and calibrating to actual loads (consumption) requires processes and technologies further described in herein, and beyond. Such processes, for example, will predict particular space type (EUI), building system (i.e. Enclosure) and sub-system (i.e. WWR) causes and energy effects, but must also resolve the interactions when placed in a whole-building as a complete system.