The Energy Simulation Report in the design process, a (potentially) powerful tool to exchange information and results

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Abstract

Energy modeling during the design process requires a large amount of information exchange between the design team members. As a result, the energy modelers need to organize and effectively communicate an immense amount of data for the design team and the client. The "Energy Simulation Report" is typically the only means by which energy modelers inform designers and clients on the project's energy consumption and related costs, as well as recommend efficient design solutions. Such a tool should be easy to navigate, comprehensive of inputs for the baseline and design models, and clearly report the simulation results.

The paper analyzes the most common types of simulation reports used to convey information and highlights the typical issues encountered. In addition, it describes the structure of the internally developed "Energy Simulation Report Framework" used to prepare energy simulation reports at each design phase in order to maintain uniformity and consistency in the reported information. The framework proved to be crucial in improving the way energy model results are presented, enhancing the communication among team members and avoiding delays due to confusion in the reported data.

1 Introduction

The role of the energy modeler within the design process has been at the forefront of the most recent debates in the field of building performance simulations. Among the many and diversified tasks required for this role is the ability to effectively convey information obtained from energy and environmental simulations to the design team and/or building's owner, by means of the Energy Simulation Report (ESR).

Depending on the type of project, project team structure, phase and scope of project, the analyses that the energy modeler performs may change significantly, and so does the report that is produced to capture the results. Moreover, the format used to compile the report should be carefully selected to ensure the most effective communication of results to the end recipients.

Currently there is no standard guide which addresses what data should be included in the ESR. The intent of the paper is to address how an effective and accurate ESR should be prepared, based on the feedback collected from energy modelers and designers. Different types of ESRs have been analyzed and compared with the objectives of highlighting strengths and weaknesses of each, as well as to share lessons learned on how common issues encountered can be solved.

2 The Energy Simulation Report as a tool for building design

ESRs can be prepared to compare the performance of multiple energy efficiency measures (EEMs) or to report results for the analysis of a unique design scheme. They can apply to a master plan, a building or a building component. The intent of this paper is not to offer specific guidelines for each of these scenarios, rather to suggest a general framework that can be used when preparing any kind of ESR across the design process.

The paper focuses on the simulation analyses and reports undertaken in order to inform the design of new and existing buildings as well as analyses performed to ensure that specific energy consumption targets are met (e.g., sustainability rating systems, energy regulations).

Influencing factors

The main factors that determine the content of the ESR are summarized below:

- **Type of Analysis:** Energy simulations can be performed to test and compare multiple design options, to assess the global performance of one preferred design scheme or to test a specific building component. Often all of these types of analyses are carried on in turn. When multiple design options are tested, the ESR may result in a very extensive document, as input/output/results for each analyzed scenario must be reported and recommendations formulated.
- **Phase of the Project:** As the project develops across the design process, more details on building envelope and systems become available thus influencing the way the energy model is built. The energy modeler has the challenging task to collect the data (simulation input) from the design team necessary to build an accurate model, and subsequently organize the data into a format suitable for the chosen software.
  The ESR must capture all relevant energy model inputs, including potential assumptions or simplifications made.
- **Project Boundary:** A simulation analysis can be performed on a building component, a single building or an entire campus. The ESR should clearly define the boundary of the analysis performed, which may or may not coincide with the project boundary.
- **End User:** The end user is a leading factor in the choice of the language to adopt when writing the ESR.
  Across the design process, the ESR is generated to convey the results of performed analyses. The recipient can be the design team, the building owner or a third party (e.g., an institution that will grant an award upon meeting a predefined performance target). The ESR should be as effective and simple as possible, still ensuring the accuracy of the reported information. The level of detail of the information included should be tailored to the end user's profile and background.

3 Types of Energy Simulation Reports: similarities and differences

ESRs collected from multiple projects of varying scope and scale have been compared and analyzed for this paper. The comparison showed that ESRs are different in the structure, contents and representation of the included information.

The most recurring differences that have been observed can be grouped in the following categories:

- Structure
- Organization of input and assumptions
- Communication of results
- Effectiveness of conclusions
- Conciseness

Each category is explained in more detail below and substantiated with examples.

Structure

Two recurring main structures have been observed among the selected samples: ones with results presented first and ones with results presented last (Fig. 1). The structure of the ESR is usually reflected in the Table of Contents; however, the Table of Contents is not always included in the ESR.

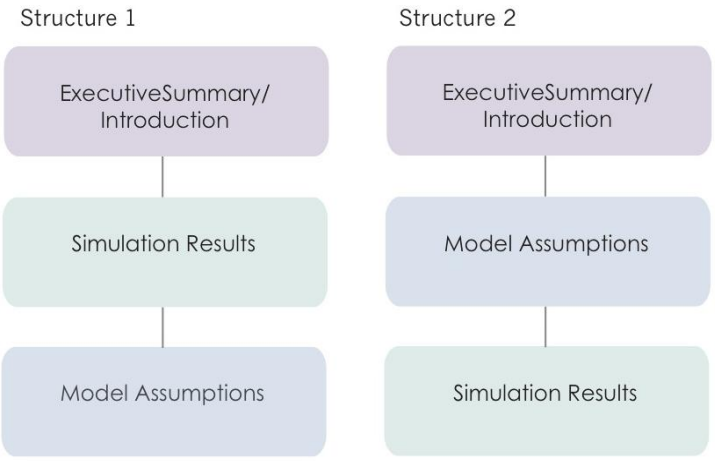

Figure 1: ESR most recurring structures

Every analyzed ESR begins with an Executive Summary/Introduction paragraph. Within the first structure type, simulation results and recommendations are explained at the beginning of the report, while details on energy modeling inputs, assumptions and calculation procedures are specified afterwards. This structure has the benefit to provide the reader with the outcome of the performed analysis right away, without having to read through the details of the energy model and analysis.

Unlike the first scenario, the second structure guides the reader through the entire procedure followed, providing the results and recommendations at the end of the report. Although this approach does not immediately provide the outcome of the analysis, it helps to ensure that the reader is aware of the procedure followed and assumptions made before viewing the conclusion, thus avoiding misinterpretation of the analysis results.

Organization of input and assumptions

Every report includes an “Input Comparison Table” (Fig. 2) that specifies differences between the baseline design of reference (e.g., ASHRAE 90.1-2004 Appendix G) and the proposed design scenario (or multiple scenarios, if more EEMs are tested).

The Input Comparison Table represents a summary of the energy modeling input and often lacks some of the relevant assumptions made when building the model. Some reports among the samples analyzed include an extensive explanation of the energy model input, reporting comprehensive information on building envelope, schedules, diversity factors, building operation and mechanical systems.

Interior Lighting Power Densities and Plug Loads During "Open to Public" Hours										
	Baseline Input Space-by-space Method Using ASHRAE 90.1-2004 Table 9.6.1				**Proposed Input** Schematic Design					
Space	General Lighting W/SF	Exhibit Lighting W/SF	Plug/Process Loads W/SF	AV Loads W/SF	General Lighting W/SF	Exhibit Lighting W/SF	Plug/Process Loads W/SF	AV Loads W/SF	Automatic Occupancy Lighting Controls	Daylight Controls
Admin Areas										
Lobbies	1.30	--	--	0.25	0.91	--	0.25	--	Yes	Yes
Reception Area	1.30	--	--	0.25	0.91	--	0.25	--	Yes	--
Office Space	1.10	--	--	0.75	0.77	--	0.75	--	Yes	Yes
Conference/Meeting	1.30	--	--	0.25	0.91	--	0.25	--	Yes	Yes
Event Space	1.30	--	--	0.25	0.91	--	0.25	--	Yes	Yes
Exhibit/Museum Areas										
Exhibit Area 1	1.00	0.65	--	--	0.80	0.65	--	--	--	--
Exhibit Area 2	1.00	9.78	--	7.60	0.80	9.78	--	7.60	--	--
Concourse	1.00	5.04	--	4.50	0.80	5.04	--	4.50	--	--
Exhibit Area 3	1.00	7.32	--	3.50	0.80	7.32	--	3.50	--	--
Exhibit Area 4	1.00	3.75	--	2.20	0.80	3.75	--	2.20	--	--
Exhibit Area 5	1.00	16.95	--	2.30	0.80	16.95	--	2.30	--	--
Exhibit Area 6	1.00	5.10	--	2.00	0.80	5.10	--	2.00	--	--
Exhibit Area 7	1.00	5.23	--	2.80	0.80	5.23	--	2.80	--	--
Exhibit Area 8	1.00	3.32	--	1.20	0.80	3.32	--	1.20	--	--
Exhibit Area 9	1.00	4.15	--	3.20	0.80	4.15	--	3.20	--	--
Educational Learning Center	1.00	6.00	--	2.00	0.80	6.00	--	2.00	--	--
Exhibit Area 10	1.30	--	0.25	--	0.91	--	0.25	--	--	--
Food Service/Retail Areas										
Cafeteria	1.40	--	0.10	--	0.98	--	0.10	--	Yes	--
Lunch Room	1.40	--	0.10	--	0.98	--	0.10	--	Yes	--
Kitchen	1.20	--	2.50	--	0.84	--	2.50	--	Yes	--
Catering	1.20	--	0.25	--	0.84	--	0.25	--	Yes	--
Retail/Sales	1.70	--	0.25	--	1.19	--	0.25	--	Yes	--
Service Areas										
Miscellaneous	--	--	--	20 kW	--	--	--	20 kW	--	--
WC	0.90	--	0.10	--	0.63	--	0.10	--	Yes	--
Plant Room	1.50	--	0.25	--	1.05	--	0.25	--	Yes	--
Storage Room	0.80	--	0.10	--	0.56	--	0.10	--	Yes	--
Outdoor	142 kW	--	--	--	128 kW	--	--	--	--	--

Figure 2: Sample Input Comparison Table

Communication of results

From the sample of ESRs studied, it is evident that there are significant differences in the way results are communicated. Some ESRs reported results using exclusively tables, while other used graphics and/or charts. Tables that report numerical results proved to be more difficult to understand than graphical representations (e.g., bar charts, pie charts) (Fig. 3).

When multiple EEMs are tested, the choice of using charts together with tables becomes more important in the effective communication of results, as the amount of information obtained from the energy simulation is larger. Also, charts showing relative difference between simulations in percentages rather than absolute values (e.g., MWh/m^2, \$/m^2) were generally easier to read and associate to the project targets, which are usually expressed in percent reduction of energy consumption and/or cost (Fig. 4).

Energy End Use Comparison		
	Baseline Design	Proposed Design
	MWh	MWh
Heating	2,169	1,928
Cooling	1,044	402
PEMB General Lighting	80	80
Exhibit Lighting	1,366	1,366
General Lighting	241	80
Exterior Lighting	80	80
AV Load	964	964
Plug Load	161	161
Fans	562	482
Pumps	803	884
Heat Rejection	241	241
DHW	321	321
TOTAL	8,033	6,989
% Energy Savings		13%

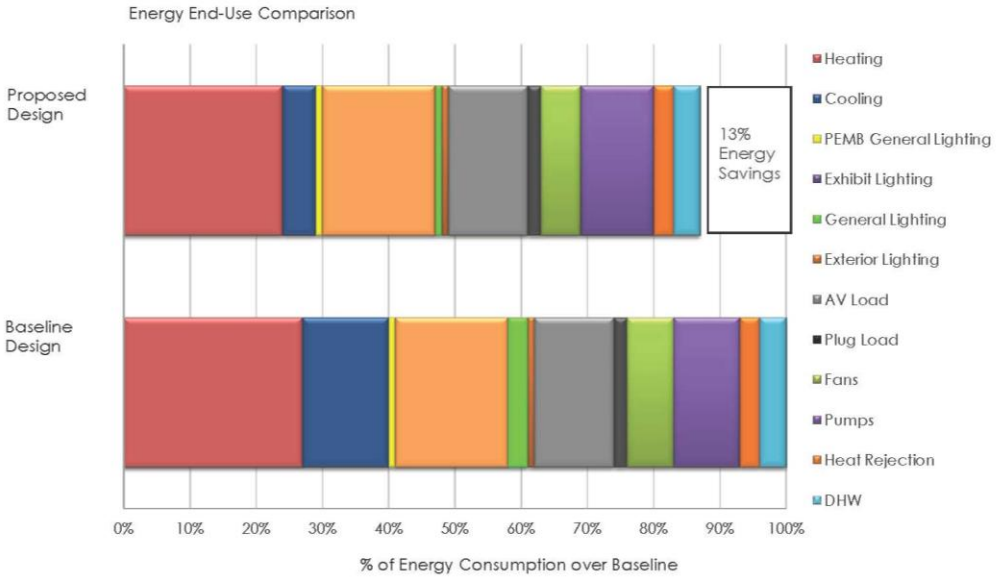

Figure 3: Sample of Building Energy End-Use results reported via table and graph

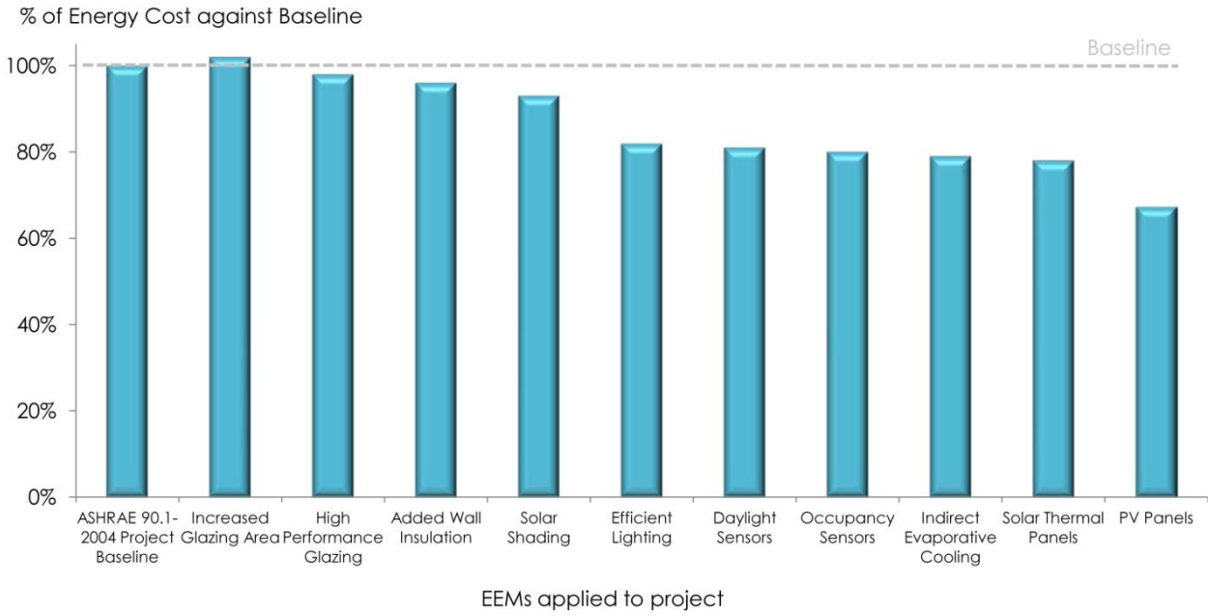

Figure 4: EEMs results reported via graph

Effectiveness of conclusions

Conclusions summarize the key results and state whether the energy reduction goals have been achieved. Conclusions are sometimes supplemented with supporting figures (e.g., percent reduction, energy use intensities).
In most of the ESRs analyzed, targeted goals for the project are anticipated in the executive summary or in the introduction paragraph, but not necessarily reflected in the conclusive statements. To ensure that conclusions are effectively communicated, consistency between the stated goals in the executive summary and the results reported in the conclusion paragraph should be maintained.

For instance, when reduction targets are mentioned in the executive summary, they should be consistent with the percent reductions reported in the conclusion paragraph (e.g., energy savings versus cost savings).

Conciseness

The ESR is often delivered to the design team to inform and guide design choices. The information contained and delivered should be as concise as possible without compromising its integrity.

One of the analyzed ESR reported excessive details about the energy simulation tool used and the calculation methods followed. In particular, it described extensively the algorithms implemented in the software for the calculation of loads, system sizing, plant sizing and economic savings. The ESR should clarify which simulation software has been used without the need of describing its computational features, unless necessary to explain certain assumptions made and/or specifically requested by the client. The ESR is not meant to be a guide to address how energy modeling is carried on, nor is a guide to the software used. The ESR is rather a tool to describe the general approach followed during the energy modeling process and to effectively convey results.

Including excessive information in the ESR may generate confusion with the risk of side tracking the reader from the original intent of the report.

4 Survey and investigation

Internal survey

A survey to collect further feedback on a sample of ESRs has been conducted on a population of designers, energy modelers, mechanical engineers and sustainability specialist (Fig. 5).

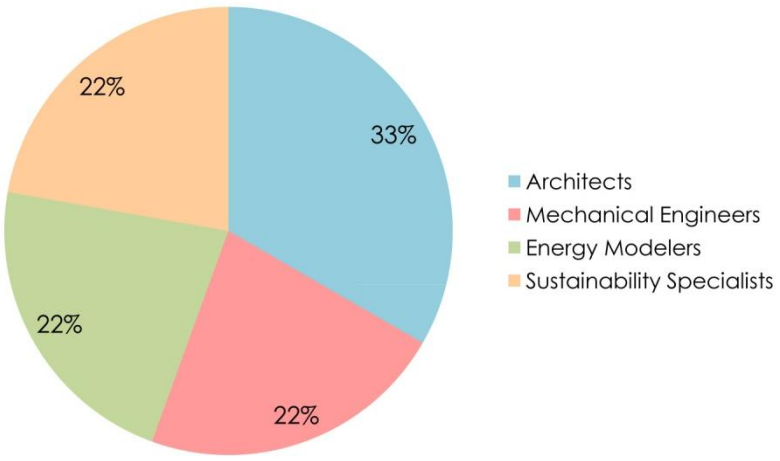

Figure 5: Survey Population Profile

The most common issues encountered by surveyees are summarized in the chart below (Fig. 6).

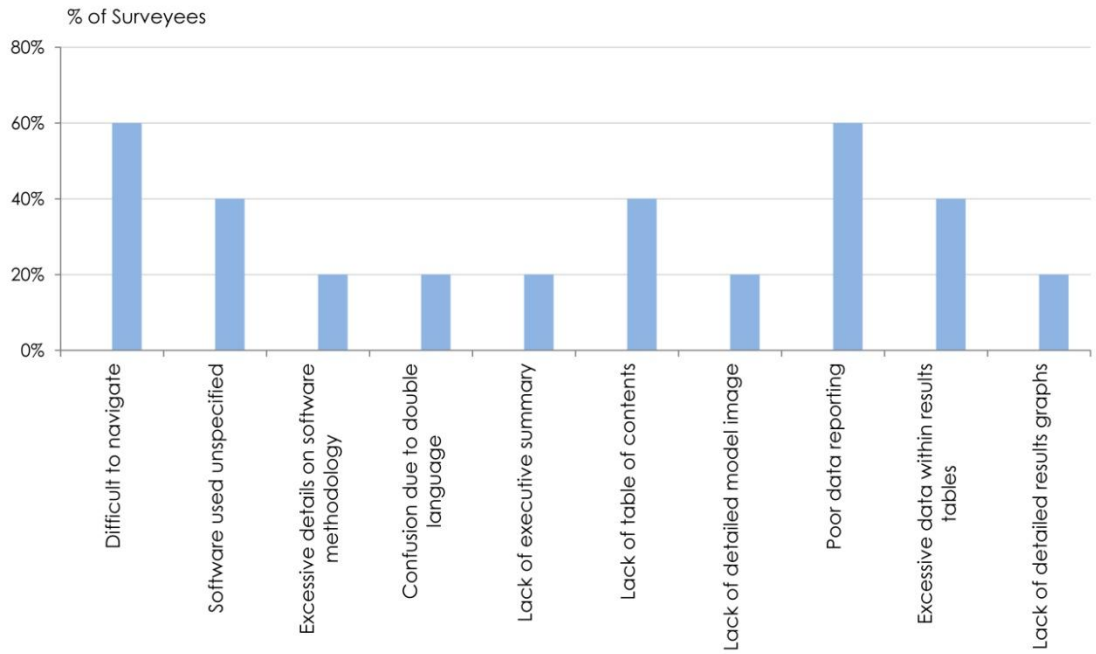

Figure 6: Major issues encountered in ESRs analyzed

About 60% of the surveyees stated that the ESRs they analyzed were difficult to navigate, in particular first time ESR readers. Most of the time this was recorded when a table of contents was missing and results were not clearly reported through charts. The entire population agreed that the conclusion paragraph (either at the end or at the beginning of the ESR) should summarize results and formulate recommendations. Model images were always received as a positive input; only 50% of the survey population expressed their preference for both general and detailed model images (with floor by floor thermal zones distribution). It was agreed that results should be effectively and concisely described in the body of the ESR, possibly highlighting (e.g., in bold) the calculated values relevant to the scope of the ESR. Extensive descriptions of outputs were sometimes preferred within the Appendix (25%). 100% of the surveyees preferred charts and visual reporting of results over tables. Surveyees with the most experience in reading/preparing ESRs expressed their preference for both general output charts (e.g., showing energy consumption) and detailed ones (e.g., showing energy end uses breakdown).

Comparison with existing research

The ESR often includes graphical representation of data, in particular of simulation results. However, ESRs are seldom prepared by authors that have received formal training in the visual arts. This often becomes clear when observing the quality of the graphics and charts reported.

The authors of this paper analyzed the existing research conducted on data visualization by Edward Tufte. Outcomes of the analysis are summarized below, focusing on the two aspects that affect data representation of ESRs the most: excellence and integrity of data.

Excellence of Data

"Graphical excellence is the well designed presentation of interesting data. [...] It consists of complex ideas communicated with clarity, precision, and efficiency. Graphical excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space." (Tufte 2001).

In the ESR, graphics are often preferred over tables for their ability to show the trends, or shape of the data and clearly communicate the information included, in particular when the amount of data represented is large.

"Information that is imperfectly acquired, is generally imperfectly retained; and a man who has carefully investigated a printed table, finds, when done, that he has only a very faint and partial idea of what he has read. […] Graphics show the shape of the data in a comparative perspective." (Tufte 2001).

Integrity of Data

"A graphic does not distort if the visual representation of the data is consistent with the numerical representation. [...] Different people see the same areas (on a chart) somewhat different; perceptions change with experience and are context dependent. […] Tables usually outperform graphics in reporting on small data sets of 20 numbers or less. The special power of graphics comes in the display of large data sets." (Tufte 2001)

Moreover, the type of graphics should be carefully selected in order to correctly represent the nature of the data. When representing data graphically, it is extremely important that the graphic representation does not induce any distortion in the way the data is perceived by the reader. To this end, the following instructions should be kept in mind:

"- The representation of numbers, as physically measured on the surface of the graphic itself, should be directly proportional to the numerical quantities represented
- Clear, detailed and thorough labelling should be used to defeat graphical distortion and ambiguity
- Show data variation, not design variation
- The number of information-carrying (variable) dimensions depicted should not exceed the number of dimensions in the data
- Graphics must not quote data out of context." (Tufte 2001).

5 How to prepare an effective Energy Simulation Report. A lesson learned

The first lesson learned is that the ESR is not a static tool with a rigid format. Rather, it is a dynamic framework that follows an organized structure that can be tailored to the project needs, development and goals.

The comparative analysis of the sample ESRs along with the energy modeling experience of the authors results in some recommendations on how to prepare an effective ESR, which are summarized below.

The ESR should have the following features:

- Dynamic, yet consistent structure
- Easy navigation
- Modularity

- Comprehensiveness of input and assumptions
- Graphical representation
- Effectiveness in the communication of results

Dynamic yet consistent structure

The ESR should be adaptable to the project's type, boundary, goals and phase. It should also be tailored to adopt the most suitable language for the end user's position and background.

However, in order to make sure that the information collected in the ESR is comprehensive and effectively summarized for the recipient, a consistent structure should be maintained for all reports produced across the design process. This is crucial to help the recipients become familiar with the ESR structure, extract the correct information and avoid misinterpretation.

A consistent structure also acts as a guide for the ESR authors to ensure that no relevant information is omitted and to expedite the writing/editing process.

Easy navigation

The ESR should always include a Table of Contents; this will help the reader navigate easily through the report. In particular, the simulation input and results should be easily available to the reader, regardless of the complexity of the report.

Modularity

The ESR should maintain a modular structure. Each section should be adeptly named and comprehensive of the subject discussed.

Comprehensiveness of input and assumptions

All relevant information necessary for the report recipient to understand the analyses performed should be included in the report. Content should be concise and targeted. More important, the reader should be able to extract the most relevant input and assumptions without having to read large quantity of text and/or numbers.

A key task of the energy modeler is to collect the project technical information from the design team members (e.g., architects, mechanical engineers, lighting designers) and convey it in a suitable format for the energy simulation software. The process of collecting these data often requires the energy modeler to prepare a "data request form" to be filled in by each design team member and returned to the energy modeling team. Developing a request form that is easy for the team to complete ensures that the correct project data are collected and that the energy model is accurately developed.

During the early phase of the project most of the input required by the energy simulation software is not available and therefore needs to be estimated or assumed. The ESR should clearly report which data have been received from the design team and which assumptions and/or simplifications have been made.

As the project develops and more data become available, the ESR should adjust to include a more extensive input section (Fig. 7).

Boilers	Baseline		Proposed	
Qty	1		1	
Efficiency	0.80		0.80	
Nominal Capacity (Watts)	autosize		autosize	
Flow	m³/sec	GPM	m³/sec	GPM
	autosize	autosize	autosize	autosize
Loading	Sequential		Optimal	

Hot Water Outdoor Air Reset	Baseline		Proposed	
	°C	°F	°C	°F
Setpoint @ Outdoor Low	82.2	180	82.2	180
Outdoor Low Temp	-6.67	20	-6.67	20
Setpoint @ Outdoor High	65.6	150	65.6	150
Outdoor High	10.0	50	10.0	50

Boiler Pump	Baseline		Proposed	
Type	Variable		Variable	
	PA	FT	PA	FT
Head	194,289	65.0	194,289	65.0
Efficiency	0.80		0.85	
Rated Power (Watts)	autosize		autosize	
Flow	m³/sec	GPM	m³/sec	GPM
	autosize	autosize	autosize	autosize
W/GPM	19.0		19.0	

Chillers	Baseline		Proposed	
Qty	2		2	
COP	4.90		5.63	
IPLV	5.60		10.80	
	W	Tons	W	Tons
Capacity	1,019,277	290	1,018,980	290
	°C	°F	°C	°F
LCHWT	6.67	44	6.67	44
ECNDWT	29.44	85	29.44	85
ChW Loop ΔT	6.67	12	6.67	12
CndW Loop ΔT	5.56	10	5.56	10
	m³/sec	GPM	m³/sec	GPM
Evaporator Flow	autosize	autosize	autosize	autosize
Condenser Flow	autosize	autosize	autosize	autosize
Loading	Sequential		Optimal	

Chilled Water Outdoor Air Reset	Baseline		Proposed	
	°C	°F	°C	°F
Setpoint @ Outdoor Low	12.22	54	12.22	54
Outdoor Low Temp	15.56	60	15.56	60
Setpoint @ Outdoor High	6.67	44	6.67	44
Outdoor High	26.67	80	26.67	80

Figure 7: Example of additional detailed input comparisons

Software used for running energy simulations can differ by the type of algorithm used to calculate results, the quantity and nature of input and assumptions requested, and the way they are inserted in the software. Vendors and professional/institutional bodies have developed comparison tables that summarize similarities and differences of simulation software approaches. Such comparisons represent great tools for assisting energy modelers in the selection of the best tool suitable for their scope of work; however the characteristics of the simulation software selected should not influence in any way the structure and the effectiveness of the ESR. The ESR should report concisely and comprehensively all input and assumptions made for the model regardless of the tool utilized.

Graphical representation

An energy model that generates a graphical representation of the building is important. Including the image of the building geometry modeled within the ESR it is an easy way to confirm that the geometry of the model as well as enclosures and shadings were properly modeled (Fig. 8).

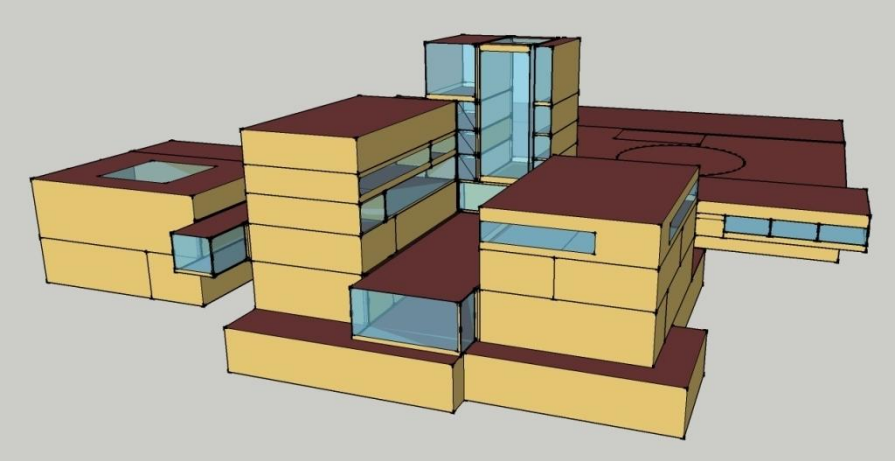

Figure 8: Energy Model image

For large and complex building with high number of programs, it may be useful to describe and show visually how building zones have been organized and grouped within in the energy model. To control the complexity and size of the model and reduce the simulation speed, energy modelers often decide to group and/or merge together thermal zones with the same program and comfort requirements. This represents an assumption that can be made depending on the level of details required for the model and its output, and when the grouping of thermal zones does not affect the accuracy of simulation results. Such assumption should be described within the ESR, and when necessary, include a graphic representation. If results are reported for a specific thermal zone, the zone characteristic and location should be clearly described within the ESR and identified on the model image.

Effectiveness in the communication of results

Effectively communicating results and formulating recommendations is a key aspect of a well-prepared ESR. Results reported using graphic representations are preferred.

All simulation tools produce output data, which the software often organizes into automatic reports with tables and graphics. Although those tables may be comprehensive, they often do not effectively communicate the results to the end user.

It is the energy modeler's task to collect the relevant simulation output and convey them in a format that is easy to read. Output data must be filtered and automatic tables and graphics should be tailored for inclusion in the ESR. This often requires the use of auxiliary tools to post-process the simulation data (e.g. spreadsheets, graphing tools). However, when feasible, simulation output automatically generated by the energy simulation tool should be attached as an Appendix for record.

When the ESR is issued for a project that has multiple benchmarks and targets multiple performance goals (e.g., Leadership in Energy and Environmental Design LEED®, EPAct, EISA for a federal project), it is crucial that results of each simulation are clearly reported. It is very useful to include a summary table of results within the results chapter (Fig. 9).

	LEED v3.0		Client's Energy Reduction Guidelines		EPAct 2005, Section 109	
Metric	% Reduction in Energy Cost		% Reduction in Energy		% Reduction in Energy	
Requirement	Minimum 10% reduction Target: 30% (10 LEED points)		30% Reduction		30% Reduction	
Baseline	ASHRAE 90.1-2007		ASHRAE 90.1-2007		ASHRAE 90.1-2004	
Note	Includes Process		Includes Process		Excludes Process	
Comparison	90.1-2007	Proposed	90.1-2007	Proposed	90.1-2004	Proposed
Units	[$/year]		[MMBtu/year]		[MMBtu/year]	
	$77,155	$65,484	4,250	3,493	4,173	3,207
	15.1% 3 LEED points EAc1		17.8% Does not meet Requirement		23.1% Does not meet Requirement	

Figure 9: Sample of Summary Table with multiple energy/cost reduction goals

This section has focused on optimized way of reporting results statically within the ESR. Software reporting tools that allow for visualizing the full range of simulation results interactively are very useful for exploring the energy model performance and looking at simulation results with a high level of details. However, such deep analyses of reported data are more suitable to energy modeling experts than to general ESR recipients who might interpret the results incorrectly. Advanced means of reporting data go beyond the intent of the ESR as described in this paper.

6 The Energy Simulation Report Framework

Starting from the recommendations listed in chapter 5, a Framework for writing ESRs has been developed. The Framework structure has been chosen based on the feedback and experiences of designers and energy modelers collected through a survey, and it is intended to be used as a guide during the preparation of ESRs (Fig. 10).

It must be understood that the ESR, thus the Framework, are dynamic tools that should be adjusted and tailored to the project needs.

The **Table of Contents** allows for an easy navigation of the ESR and informs the user on the ESR selected structure.

Each chapter is comprehensive and independent from the other and can be understood as a stand-alone part of the report. This feature allows for tailoring the ESR structure to the project needs, as well as providing the reader with a flexible reading, not necessarily tied to the ESR structural order (Fig. 11).

The **Executive Summary** and **Introduction** provide the intent of the ESR, general project information and project goals. These sections also reference any previously issued versions of ESRs, in order to give the reader an inclusive view on the project documentation history.

The **Model Description and Inputs/Assumptions** section is the core of the ESR. Along with the model image and technical information on the simulation software in use, this section includes an extensive list of the data collected and manipulated for the energy model. To enhance and expedite the collection of input from the design team, an Input Request Checklist has been developed. The Checklist has a very distinct function from the input tables; input tables summarize input and assumptions made in the model to provide the ESR reader with a clear idea of how the model has been built. The Input Request Checklist is a tool that energy modelers use before writing the ESR, to collect all the relevant project data that will be used to generate input and make assumptions for the energy model. It is in the form of

a spreadsheet inclusive of an extensive list of input required for the energy simulation, and has been prepared following the LEED template for EAp2/EAc1. It is an important means of exchange of project information between building designers and energy modelers.

1. Table of Contents

2. Executive Summary/Introduction
   - Scope of ESR
   - Recipient of ESR
   - Project location and features
   - Project boundary VS analysis boundary
   - Project phase
   - Project goals
   - Reference to previously issued ESR (if any)

3. Model Description and Inputs/Assumptions
   - Model image
   - Simulation software
   - Compliance path/paths
   - Weather file
   - Input data source
   - Input comparison chart (baseline of reference VS proposed design)
   - Comprehensive input description
   - Simplifications/Manipulation of project data due to software limitations
   - Assumptions due to unavailability of data

4. Simulation Results
   - Summary results graph/chart
   - Summary results table

5. Conclusion/Recommendation
   - Simulations outcome VS project goals
   - Recommendation (if any)

6. Appendix – Additional Data
   - Extensive input table/chart (if needed)
   - Extensive output tables

Figure 10: ESR Framework

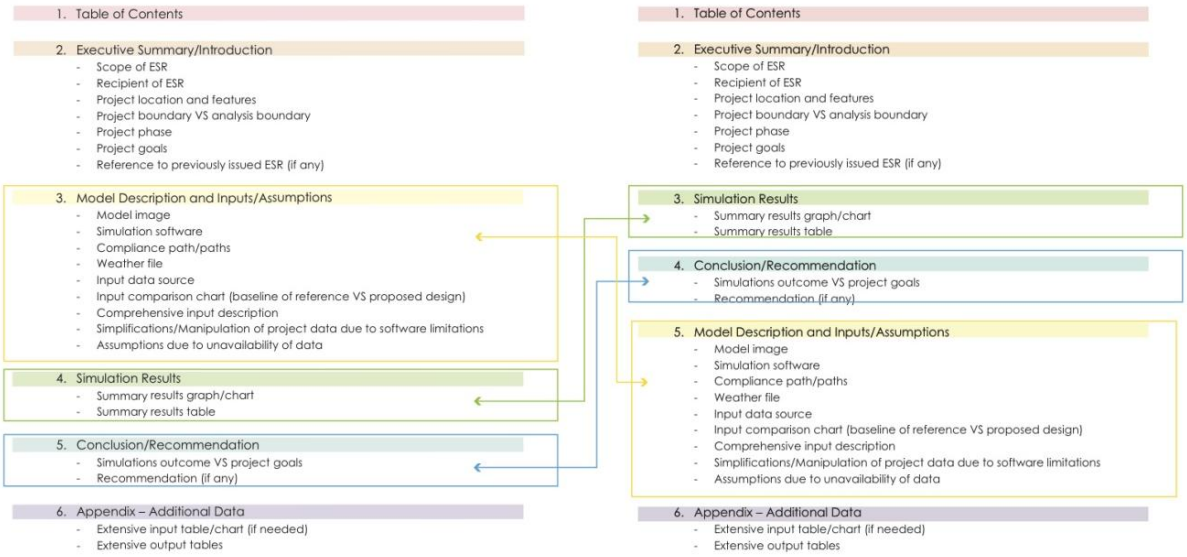

Figure 11: Adaptability of the ESR Framework Structure

The **Simulation Results** chapter includes results of the analyses performed in a readable and user friendly format. The challenge of this chapter is to select only the relevant information that needs to be communicated to the reader and present it in the most effective way.

The **Conclusion/Recommendation** section uses the simulation results to inform the reader on the status of the project performance towards the targeted goals. It also formulates recommendations. It is important that results and conclusions are consistent with the project scopes as outlined in the Executive Summary/Introduction chapter.

Extensive output tables, as generated by the energy simulation tools and/or manipulated by energy modeler, should be attached in the **Appendix/Additional Data** section. Although it is the reader's right to have full access to the generated data, it is his/her own choice whether to read it or not. Including extensive output tables within the Appendix helps maintaining a succinct and concise structure of the ESR, still providing the reader with the full simulation outcome.

7 Conclusions

Based on the authors' experience, it has been determined that there is a specific need for ESRs guidelines within the building energy simulation field.

The developed guidelines are meant to help the ESR writers in expediting the writing process as well as to ensure the delivery of effective and accurate information. The internal use of the ESR Framework on multiple projects proved to have accomplished such goals. Further surveys on the feedbacks of ESR readers are currently in progress.

In addition to providing internal guidance on how to write ESRs, this paper also hopes to encourage a broader discussion on the need of introducing standard ESR guidelines in the industry. The existence of a recognized and standard framework for the preparation of the ESR would be of great benefit to the ESRs writers, readers and ultimately building owners.

8 References

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