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SUBJECT: **Program Advisory Committee (PAC) Agenda**

Date: **December 14, 2011 -- 9:00am – 3:00pm PST**

Agenda Items:

- Project overview
    - Presenters: Martha Brook (CEC), Dimitri Contoyannis (AEC)
    - What/when/why?
    - Project Team
    - Schedule
- Purpose of PAC
    - Presenters: Martha Brook (CEC), Dimitri Contoyannis (AEC)
    - Participants
    - Expectations
- Compliance Engine Project Overview
    - Presenters: Martha Brook (CEC), Dimitri Contoyannis (AEC)
    - Overall software project summary
- Data Model Overview
    - Presenters: Diane Pepetone (L'Monte), Rob Hitchcock (Hitchcock Consulting)
    - "High-level" model for compliance analysis vs. "Detailed" BEM
    - Review of SDD XML
    - Mapping to existing data models (gbXML, IFC)
- Ruleset Overview
    - Presenters: Jason Glazer (GARD Analytics), Scott Criswell (Wrightsoft)
    - Review of Rule syntax
    - How rules are processed by compliance engine
- Compliance Engine Software Functional Requirements
    - Presenters: Scott Criswell (Wrightsoft)
    - Detailed review of the compliance engine functionality
- Simulation Engine interaction
    - Presenters: Elaine Hale (NREL), Scott Criswell (Wrightsoft)
    - Data translation
    - Simulation control
- User Interface Requirements
    - Presenters: Dimitri Contoyannis (AEC), Scott Criswell (Wrightsoft)
    - Minimally featured graphic user interface
- Compliance Forms
    - Automated forms generation process
- ACM Reference Method
    - Presenters: Martha Brook (CEC), Dimitri Contoyannis (AEC)
    - Software testing procedure
- Pilot Projects (X min)
    - Presenters: Martha Brook (CEC), Dimitri Contoyannis (AEC)
    - 3rd Party adoption of the Compliance Engine

Project Overview

The Warren-Alquist Act (WAA) requires the Energy Commission to "develop a public domain computer program which will enable contractors, builders, architects, engineers and government officials to estimate the energy consumed by residential and nonresidential buildings" (WAA 25402.1) in order to implement the requirements of Section 25402 (a) and (b), which are the prescriptive and performance building efficiency standards, respectively. The Energy Commission has contracted a technical support team of building science professionals to design, specify, develop and test these analysis tools.

The Energy Commission intends to use this building science technical support project to begin the process of collaboratively developing, testing, documenting, and supporting open source building energy modeling software and other building energy analysis tools used for Standards development, Standards compliance and other energy efficiency and clean energy public policy implementation. The project team has established a Program Advisory Committee to promote participation in these collaborative development efforts. It is the intent of the Energy Commission to migrate these building energy modeling and analysis tools into an open source forum, therefore the software developed in this Agreement will be open source and made available through an open source license recommended by the PAC and approved by Energy Commission.

The project team is led by Architectural Energy Corporation (AEC) with the support of several subcontractors who have been selected for their subject matter expertise. Refer to Appendix 1 for a list of the project team.

The Energy Commission is currently in the process of developing updates to the Standards that will be adopted by the Energy Commission in 2012, published with the entirety of the updated California Building Code in 2013, with a January 2014 implementation date. The Energy Commission is calling this energy code update the 2013 Building Energy Efficiency Standards.

It is important that the building industry have access to Standards compliance software as close to the 2013 Standards adoption date as possible. Building industry stakeholders need to understand the impact of the 2013 Standards on newly constructed buildings so that they can make the necessary adjustments to their building design and construction practices to be in conformance with the new Standards. A project schedule has been attached in Appendix 2.

Purpose of PAC

The PAC consists of industry experts knowledgeable in the fields of energy simulation, mechanical system design and operations, members of the trades who will apply the results of the project, software product developers, professionals with open source software management experience, and California utility representatives with program responsibilities in areas requiring building energy simulation tools. A list of PAC participants is included in Appendix 3.

The purpose of the PAC is to provide guidance, input, review, and comment to the project team. They will be asked to review and provide specific suggestions and recommendations for needed adjustments, refinements, or enhancement of the project deliverables. The project team will also seek the PAC's input on the process of migrating compliance software and building energy modeling tools to an open source forum and the associated computer hardware needed to house the open source software applications and data. The PAC will also be asked to provide recommendations regarding information dissemination, market pathways, and further collaborative opportunities relevant to tools developed in this project.

The project team anticipates 3-4 PAC meetings throughout the duration of the project. An agenda and relevant technical materials will be provided to the PAC in advance of each meeting in order to stimulate the discussions.

After each PAC meeting, relevant issues raised during the meeting will be summarized and distributed for further follow up.

Compliance Engine Software Overview

The Compliance Engine software will be the basis for the 2013 Nonresidential Standards public domain compliance software, encapsulate the 2013 Nonresidential Standards ACM Ruleset, will utilize OpenStudio to perform energy simulations, will be capable of producing the 2013 Nonresidential Standards Compliance forms, and will be capable of being incorporated into third party software tools. The Energy Commission provision of this public domain compliance software is a requirement by law, but it is expected that the majority of building projects will prove code compliance using third party compliance software. Figure 1 on the following page illustrates the overall vision of the software modules, their connections/ interfaces and how they fit into the final product.

A simplified interface will be developed for the public domain compliance software that allows users to describe the PROPOSED building compliance models. The interface will have a minimal feature set. It will allow users to add or edit compliance related building and system elements but will not be intended to have the feature set of a commercial energy modeling software program. Refer to the section "User Interface Requirements" for additional details on the interface functionality.

User inputs into the interface will be restricted to terms found in the Title 24 Standards Data Dictionary (SDD). The SDD is a controlled vocabulary derived from the requirements of Title 24, Part 6 and the ACM. User inputs will be communicated to the Compliance Engine for rules processing in the form of the SDD XML file. Refer to the section "Data Model Overview" for additional details on the Standards Data Dictionary and the SDD data model.

The Standards ACM Ruleset will be developed to contain all of the logic necessary to transform the PROPOSED building compliance model into the BASELINE building compliance model. The rules will be written in a clearly defined syntax and will be communicated in a series of text or CSV files that will be read and compiled by the Compliance Engine software. Refer to the section "Ruleset Overview" for additional details on the ruleset and rule syntax.

The Standards Compliance Engine is the core of the software developed for this project and will be capable of receiving the proposed building energy model XML file, processing the ruleset on the building and automatically creating the baseline building model, launching simulations in an external simulation engine, and generating compliance forms. Output data and compliance forms may then be passed back to the user interface application(s).

For the public domain compliance software produced in this project, the Compliance Engine will interface with EnergyPlus via the OpenStudio API. The SDD XML file will be passed to OpenStudio. OpenStudio will perform a translation between SDD XML and its native data model. OpenStudio will then launch the EnergyPlus simulations. Finally, OpenStudio will pass the results of those simulations back to the compliance engine. Refer to the section "Compliance Engine Functional Requirements" for detailed information on the design and operation of the Compliance Engine software. Also, refer to the section "Simulation Engine Interaction" for additional information on the Compliance Engine's interaction with OpenStudio.

The system is designed to be "vendor neutral" meaning that it can ultimately interface with multiple user interfaces and simulation engines. Pilot projects will be pursued with alternate vendors and simulation engines as described in the section "Pilot Projects."

The Standards Compliance Forms Generator module will receive results of the compliance analysis and transform them into a report suitable for submission to local permitting authorities. Refer to the section "Compliance Forms" for additional details.

The software will be used as the basis for the ACM Reference Method. The ACM Reference Method describes a series of quantitative tests of various building and system design strategies and their associated simulation results. The tests will be clearly defined in terms of the modeling inputs and outputs. Software programs seeking to become certified ACM programs must comply with the Reference Method testing procedures. Refer to the section "ACM Reference Method" for additional details on the testing procedures.

Figure 1 - Compliance Engine Software Diagram
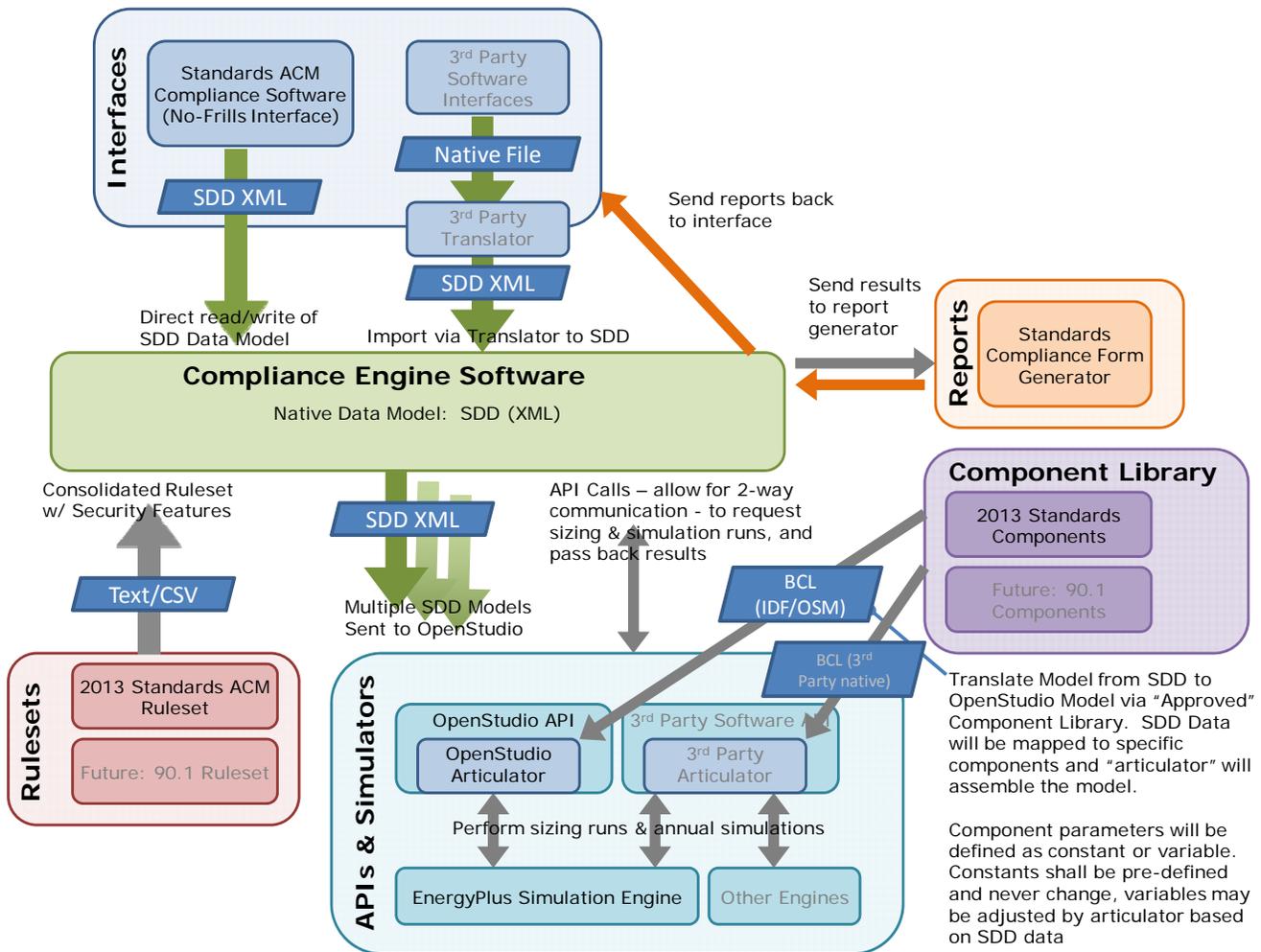
Data Model Overview

A controlled vocabulary has been derived from the requirements of Title 24, Part 6 and the ACM and is called the Standards Data Dictionary (SDD). A hierarchical data model has been developed using the terms in the SDD as a means to organize the terms in a relational structure. An XML file and schema has been developed that directly corresponds to the SDD data model, and is called the SDD XML. The SDD XML file will be used as the interchange format between a user interface and the Compliance Engine software.

An important distinction must be made between a "Standards Data Model" and a "Building Energy Model" (BEM). The Standards Data Model represents all building parameters needed to trigger energy standards rules, and parameters that are set by the rules. The BEM model contains all of the detailed parameters necessary for an energy simulation engine. It is defined with respect to a specific energy simulation tool, and a variety of BEM data models are currently in use (e.g. IDF, BDL, etc.).

While there is considerable overlap between the Standards and BEM models, elements in the Standards model tend to be more generic, have less detailed representations of input parameters, and may have unique terms needed to process rules, though not necessarily used for an energy simulation. For example, the Standards Model may contain fenestration system parameters such as U-value and SHGC, whereas a BEM model may require fenestration assemblies to be input by specifying multiple layers of glass, air cavities, film coefficients, and other detailed thermal data.

There are currently numerous ongoing efforts related to interoperability of data exchange formats including the development of Industry Foundation Classes (IFC) and Green Building XML (gbXML). The project team has been actively engaged in discussions with an interoperability work group led by the US DOE with support by several National Laboratories. Their effort is geared towards finding convergence or developing translators between these data standards. This Compliance Engine project team has not adopted one of these standards for use as the SDD XML because they are built for use in BEM interoperability and contain a higher level of detail than is needed for a Standards Model. However, the team intends to leverage the interoperability efforts by ensuring that the SDD XML is developed such that it is compatible with, consistent with, mapped to data elements in, or translated to related data in these interoperable data models.

A brief overview of the Standards Data Dictionary, data model, and XML format will be given during the PAC meeting.

Ruleset Overview

The ruleset contains all information specific to performing Title 24 compliance analysis. The ruleset is capable of operating on a user-input hierarchical building data model, and performing transformations in order to generate the proposed and baseline building models used for compliance analysis. The ruleset will be developed as an independent module of the software and rules may be edited without modifying the Compliance Engine source code. A potential benefit of this modular approach is that it allows for other rulesets to be developed in the future to address other energy codes, green building rating systems, and beyond-code incentive programs without the need to modify source code.

Syntax for creating the ruleset has been developed and is referred to as the "Data Model Ruleset." Each rule is based on a specific data element from the hierarchical data model. Processing of the rules will create a series of similar but modified hierarchical building data representations for the proposed model and the baseline model. For example, if the Standard consisted of only two rules that required a minimum amount of insulation and a maximum amount of lighting power, the resulting baseline hierarchical building data representation would look

almost identical to the user's hierarchical building data representations except the data items related to insulation and lighting power would likely be altered.

The ruleset syntax will allow rule authors to define rules which utilize lookup table values, perform any necessary intermediate calculations as part of a rule's processing, remove or replace elements of the data model, and perform multiple transformations on the proposed and baseline models. The syntax will also contain descriptive text to describe the rule, help file documentation, references to the section of the Standards from which the rule was derived, minimum and maximum values for data inputs, and allowable enumerations where applicable.

The ruleset is completely described using text files. The files should be organized by topic but this is for the convenience of the rule developers, since ultimately the contents of all files are compiled together. No file is the "main" file. Dependencies of the rules in the files are determined on an expression-by-expression basis so no ordering of the files is required. Circular referencing would be flagged by the compiler and identified so the rule author can correct.

A brief overview of the ruleset will be presented at the PAC meeting along with specific examples of rules written in the Data Model Ruleset Syntax.

Compliance Engine Software Functional Requirements

The Compliance Engine software has four major functions:
1. *Producing the compliance ruleset for distribution to end users* - the Compliance Engine will consolidate numerous ruleset files into a single file to minimize the number of files needed. During this consolidation, the Compliance engine will have the ability to detect and report compliance rule circularities. Additionally, appropriate security features such as a digital signature or similar mechanism will be used to verify the authenticity of the T24 ruleset.
2. *Utilizing ruleset data to perform compliance analysis* – the ruleset is designed to transform various attributes of a proposed building model to determine whether or not the building complies with the energy code. The Compliance Engine must be capable of parsing the ruleset and applying the building model changes identified in the rule expressions into a building description. Features to support this capability include:
    a. the ability for the Compliance Engine to read and write the SDD XML file format
    b. An API that allows interface tools to retrieve and set the SDD model data
    c. The ability to confirm the validity of the Proposed Building model
    d. The ability to process the compliance rules in the proper evaluation order
    e. The ability to process the ruleset
    f. The ability to manage multiple building models
3. *Managing the simulation of compliance energy models* – The Compliance Engine will be capable of initiating building energy simulations by interacting with a simulation engine. For the public domain software, EnergyPlus will be used as the simulation engine, and this feature will be called the "E+ Interface." These simulations typically fall into two individual categories, (a) simulations performed to determine whether or not HVAC equipment sizes and flows are sufficient to adequately condition the building, and (b) final/annual simulations, the results of which are compared to determine compliance of the proposed building model to the Energy Code. The Compliance Engine need not keep track of whether a given simulation is of one type or another (sizing vs. annual), as it is the ruleset's responsibility to setup the SDD building transformation with all data needed to perform a specific type of simulation.

4. *Reporting Compliance Calculation Messages and Results* - There are three primary sources of errors, warnings or other messages that need to be communicated to the user or calling application as well as a compliance log file. Those sources include:
    a. The compliance ruleset, which contains building attribute range limits as well as the ability for rules to initiate messages of various severity,
    b. The E+ Interface, which can report issues related to the data stored in the SDD building model passed to it for simulation or messages returned by the EnergyPlus simulation engine, and
    c. The Compliance Engine itself, if certain aspects of the rule processing or SDD building model is somehow compromised in a manner that disrupts the analysis.

Simulation Engine Interaction

The Compliance Engine will interact with a simulation engine to perform three main functions:

1. *Generating input files* – this will be performed by a translator between the SDD XML and a simulation engine's native data model. In the case of the public domain software, the translation will occur between SDD XML and OpenStudio Model (OSM) to allow for simulation in EnergyPlus. Since the SDD is a high-level building model, a number of details of the fully described energy model input file will need to utilize smart default values, either directly in the translator or by utilizing pre-defined components stored in a Building Component Library (BCL). Examples of detailed components may include schedules, constructions, or baseline HVAC systems.
2. *Simulation workflow management* – The simulation engine interface must be capable of initiating and managing the simulations of each translated file. In the case of the E+ Interface, the OpenStudio Run Manager may be utilized to achieve this function. The interface will monitor simulation status and provide any simulation error or warning messages.
3. *Retrieval of simulation results* – The simulation engine interface must be capable of retrieving results of each simulation and making them available to the Compliance Engine. Results may be written to CSV or XML format. OpenStudio does support XML output reports, and TDV calculation support.

User Interface Requirements

The public domain compliance software interface will enable users to create and edit proposed building designs (based on the SDD data model) and to initiate (through access to the Rules Engine) automated Title-24 compliance analysis on those models. The UI Tool should provide clean, clear and efficient access to the entire SDD data model, but will not include wizards, mouse-driven geometry construction or highly graphical building or HVAC system diagrams, so as to minimize the potential for this tool to compete with other commercial energy code compliance user interfaces.

The user interface will support SDD XML as its native file format and will be capable of reading and writing files in this format. The interface will be capable of displaying components of the active/loaded SDD model in a hierarchical manner that shows the parent/child relationships of components in the model. In addition to displaying component relationships, the user interface must be capable of editing those relationships, creating new components and deleting existing components. Additionally, model defaults will be displayed through the interface.

A functional requirement being considered is the capability for the User Interface to display baseline model parameters beside each input field to provide users with real-time feedback on how their building design inputs compare to the code baseline inputs.

A brief overview of the User Interface Requirements will be presented at the PAC meeting.

Compliance Forms

The Compliance Engine will have the capability of automatically generating compliance forms for submittal to local permitting authorities. Plans for this functionality will be discussed at a future PAC meeting.

ACM Reference Method

The ACM Reference Method testing procedure will be a series of simulations to be performed by candidate compliance software to demonstrate that their performance is acceptable for use in code compliance. The results of the simulations will be compared to reference results obtained by performing EnergyPlus simulations. The tests will utilize a series of prototype models, with the test cases being specific variations to the prototype models. The test cases will be defined in a spreadsheet which lists the prototype building model, climate zone, and model inputs used for each test.

The test case variations will be described at a relatively high level, but will include details of the implementation in EnergyPlus. Reference simulation results from EnergyPlus for each test case will be compiled in a spreadsheet and will include electricity and gas consumption for each energy end-use as well as overall TDV and electric demand results. The results obtained from the candidate compliance software will be compared to the reference results to verify that compliance software meets the requirements of the ACM, although details of the passing criteria are to be determined.

Additional details of the Reference Method tests will be discussed at the PAC meeting.

Pilot Projects

The Energy Commission expects to pilot the Compliance Engine software with qualified software vendors. There are currently many third party energy analysis tools in use in California. By allowing a broad sampling of vendors to participate in the pilot, the opportunity for increased performance and compliance modeling will be a natural outcome and will result in buildings that are more efficient.

A key requirement of the Compliance Engine software will be its capability to interact with 3rd party software interfaces and simulation engines. The project team has developed a modular software tool with standardized data exchange features to accommodate the use of alternate user interfaces and simulation engines.

Qualified vendors will be provided with detailed specifications outlining the required data formats for input and output files, the API and documentation on how their tools must interact with the Compliance Engine, and testing criteria that must be met to be considered a successful pilot. Additionally, pilot participants will be given specific requirements on how they must document their tests such that it can be reviewed by the project team and the Energy Commission.

Several 3rd party software vendors will be represented at the PAC meeting, and the pilot project process will be on the agenda to solicit feedback from these vendors.

Appendix 1 – Project Team
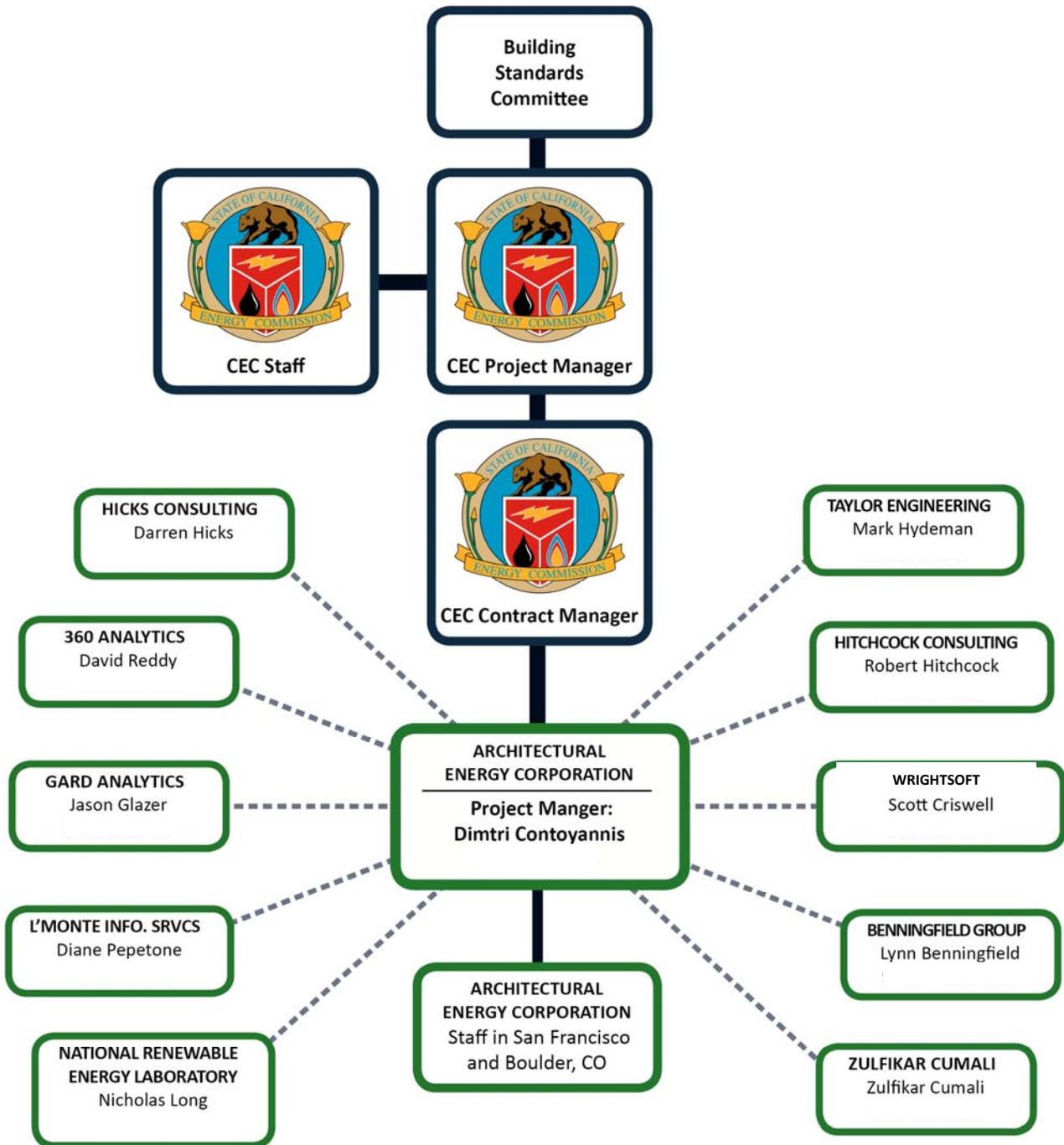
Appendix 2 – Project Schedule

A Project schedule will be distributed prior to the first PAC meeting.

Appendix 3 – PAC Participants

A list of PAC Participants will be distributed prior to the first PAC meeting.