User Requirements and Software Capabilities for AEC
Life Cycle Assessment

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REPORT

Introduction: Life Cycle Assessment adds value to the AEC industry by allowing designers to quantitatively evaluate the sustainability of materials. This case study applies LCA software tools to design decisions for the Stanford University Green Dorm. We focus on the choice between a steel or wood structural system, investigating how quantities of materials can be minimized, or substituted with ecoPreferred products. Results show that software tools and user requirements are not aligned. This report focuses on the application of the Athena Environmental Impact Estimator and LCADesign.

Methodology: Successful LCA tools must provide results in a process complementary to the existing workflow of AEC practitioners. For this case study, the professional design team defines building characteristics and the researchers apply LCA tools. Narratives[1] record the process, showing the disjunction between AEC practice and LCA studies. ISO 14040 requires that four phases be carried out in an LCA: goal and scope, inventory analysis, impact assessment, and interpretation. Software tools need to facilitate the completion of each LCA phase while allowing the building parameters to be modified with ease.

Athena Environmental Impact Estimator: A completed design, with simple geometry is well analyzed with the Estimator. The Estimator uses a series of dialogue boxes to gather inputs. While these dialogues are simple to use, they are not easy to modify. The

[1] Narratives: formal, visual descriptions of the design process that include representations, reasoning and interrelationships

Estimator does not create a visualization of the model, either in the form of a picture, hierarchical tree, or table. Without a visualization, it is difficult to ensure that all components have been imputed. Materials added in “Define envelope” are not displayed on the tree. Therefore, there is no model to help users visualize the scope/boundaries of the model. We created a table of inputs in Microsoft Excel to track each object (fig. 1).

LCADesign: The prototype LCADesign calculates the embodied environmental impacts from a 3D building information model (BIM) represented in the global standards-based Industry Foundation Classes (IFC) format. The value of model-based LCA comes from the project work environment. As more firms use BIMs, it becomes realistic to envision a streamlined process for completing LCA studies based on automated quantity take-offs. The process consists of defining the goal and scope, customizing inventory, creating reasoning rules, tagging and exporting the BIM, and analyzing results (fig.2)

Creating Model: During the feasibility study the architect did not create a BIM. We developed the BIMs from sections and 2D floor plans (fig. 4-5). As firms transfer their design methodology to BIM, model-based LCA will see huge timesaving, since the same model created by the architect can be adapted for LCA.

LCADesign currently requires the input of a tagged 2.0 IFC model from ArchiCAD 9. This is a tremendous drawback to applying LCADesign to actual case studies. LCADesign is working to change this, and in the next release will not be tied to any single modeling environment. That said, we will briefly describe our experiences with the existing environment. ArchiCAD 9 limits the ability to build models. The current release of the software, version 11, is much easier to model with, but current LCADesign add-ons cannot be added. These experiences show that a successful model-based LCA tool must have a ubiquitous modeling and tagging environment that is not dependent on a single BIM software.

Customizing Inventory: Two phases of data customization were required to create the database used in the project. LCADesign runs from the Boustead Database. In phase one, the CRC for Construction Innovation's master European database was adapted for use in the United States by correctly modeling the energy grid, imports, and distribution of natural resources. Actual manufacturing processes were not re-calculated based on the assumption of developed nations using similar technologies to generate bulk materials. In phase two, local supply chain data was gathered for the critical materials: wood, steel and concrete. Modeling local supply chains for the principle materials required contacting a representative selection of firms to determine their location and sources of raw materials. Decision trees summarize (fig. 3) the data and compute averages, which were then inputted into the Boustead database to create the final customized database. The process of gathering local data created more pain than value. Customized transportation distances were approximately equal to the generic distances. More important than customized data, designers need better tools to visualize data supply chains to understand the meaning and impacts of the data.

Conclusion: The AEC industry is in a state of transition between 2D drawings and model-based design. Thus, both Athena and LCADesign have value today. Looking to the future, neither is optimal. As researches at Stanford University's CIFE, we see huge value for firms in model-based design to improve the integration of LCA into their design processes. We encourage the development of model-based tools that allow greater data transparency and easier tagging of materials.

Images

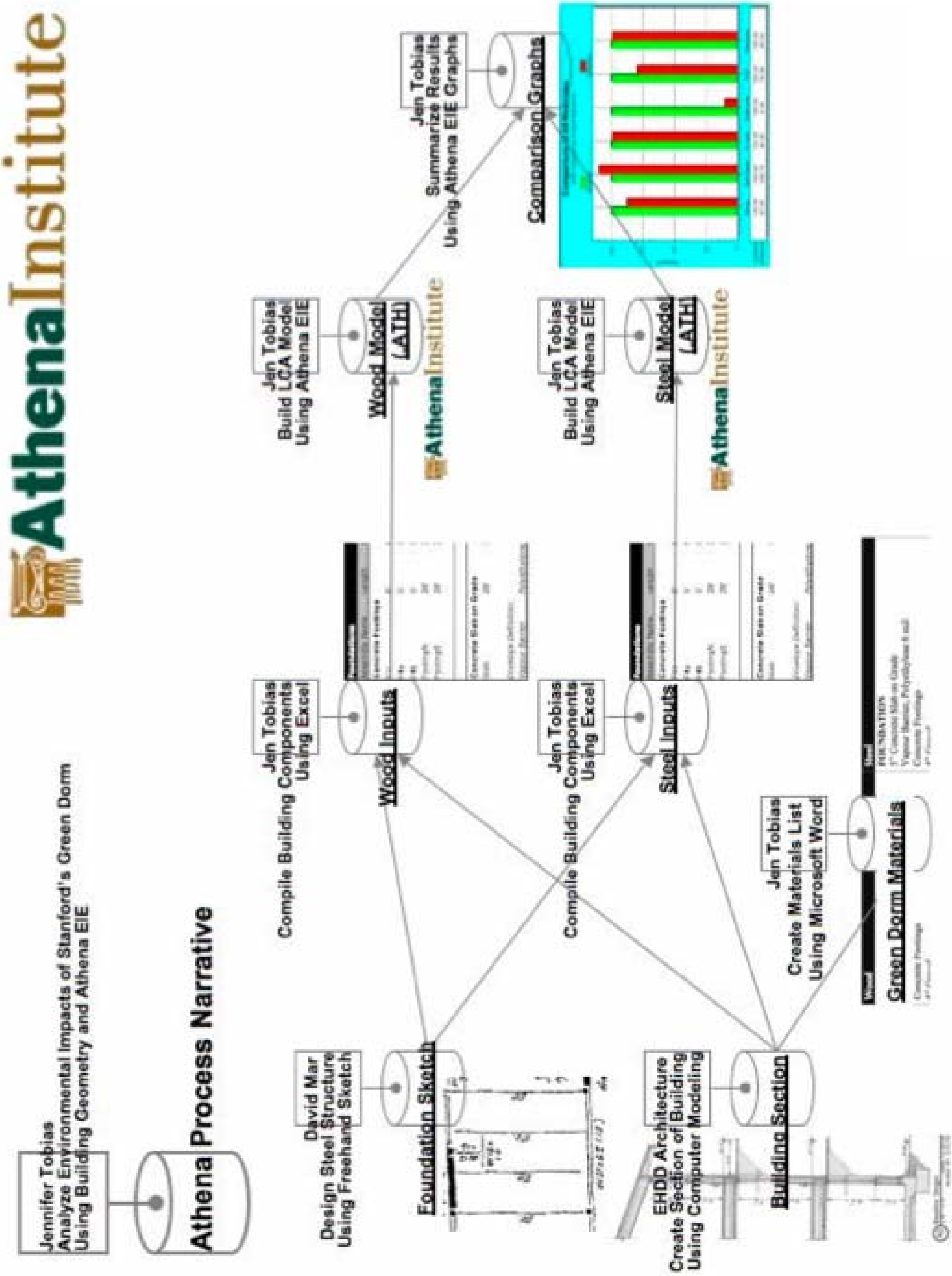

Figure 1: Narrative of Athena process. (Tobias and Haymaker)

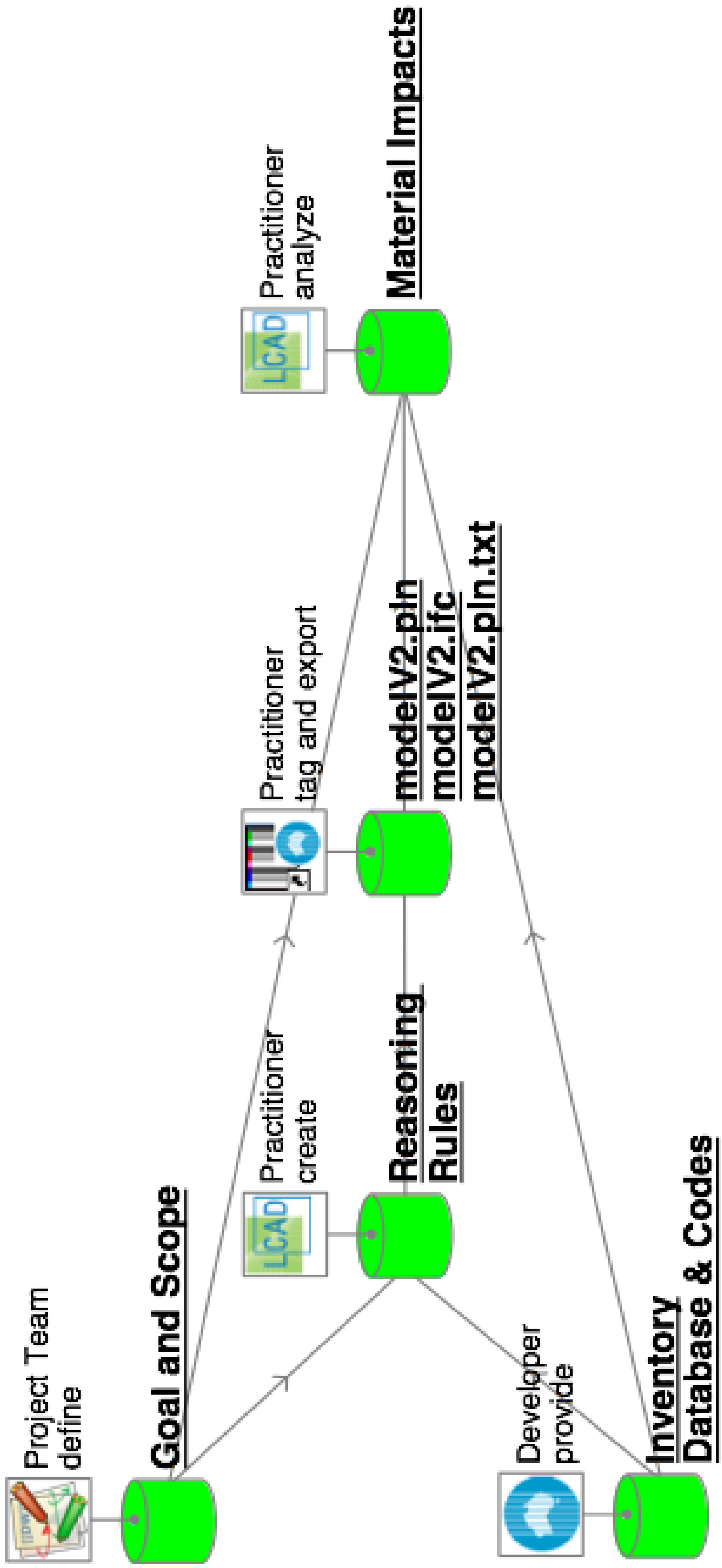

Figure 2: Narrative of LCADesign Process (Tobias and Haymaker)

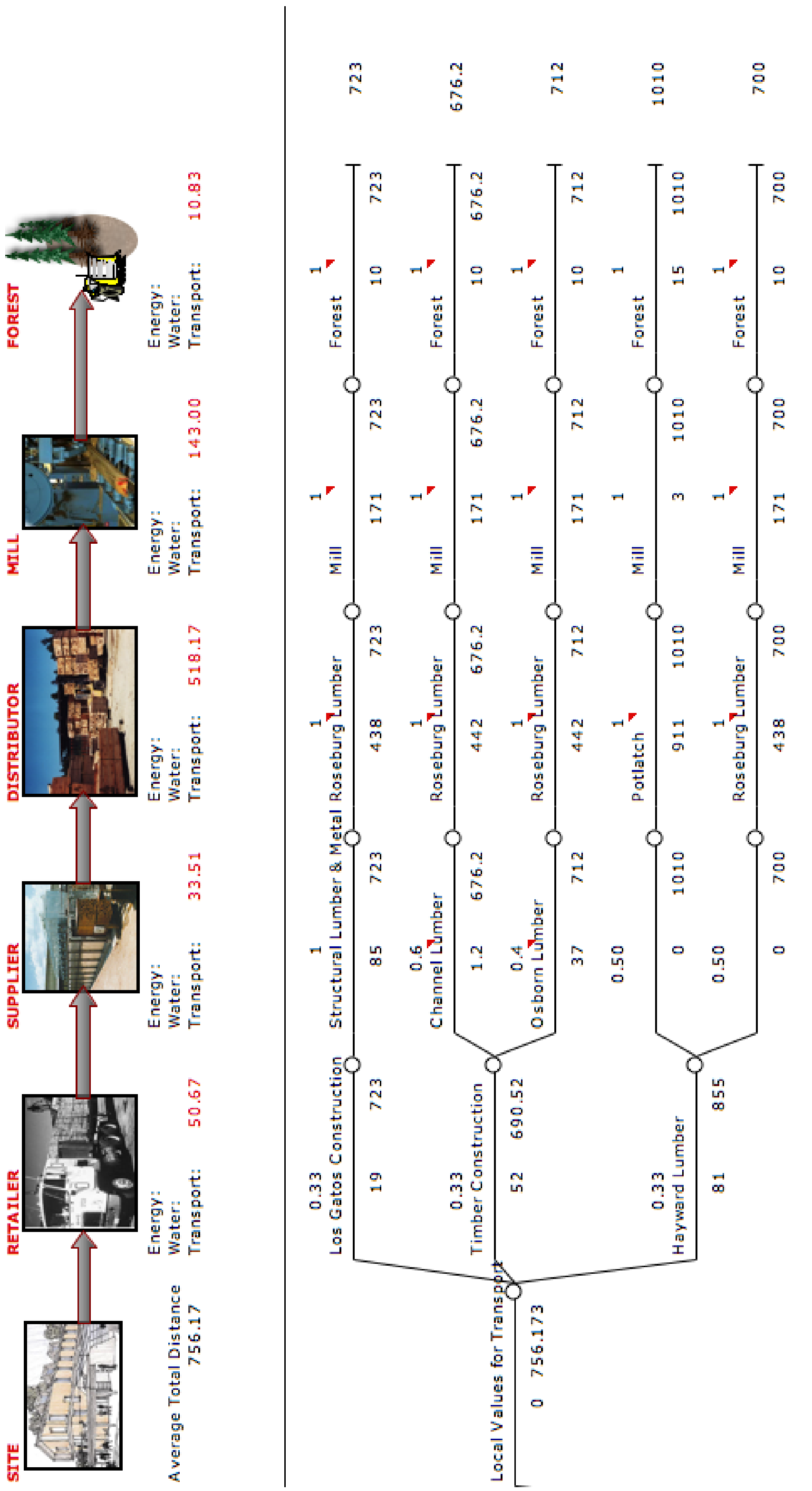

Figure 3: Decision tree showing local supply chains

Addenda

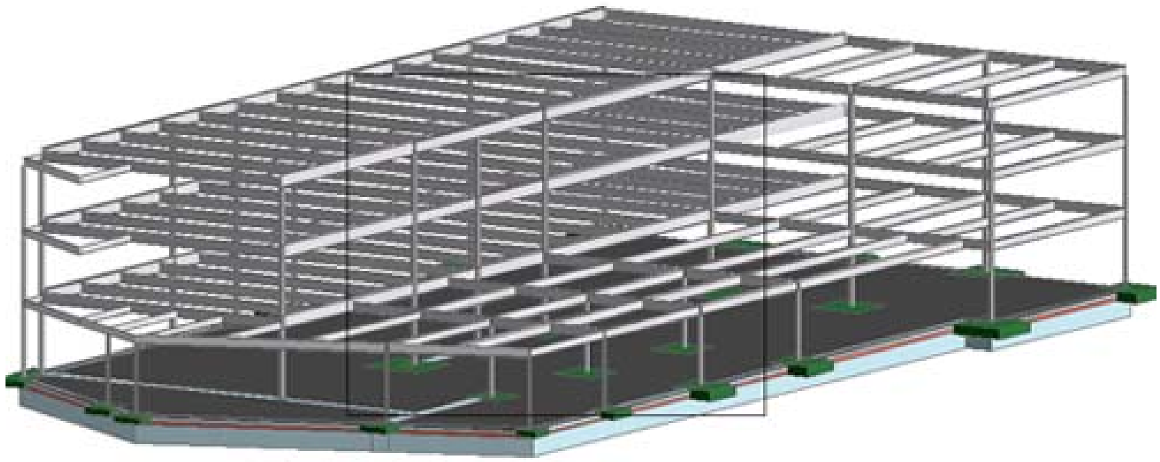

Figure 4: Steel Model (Tobias)

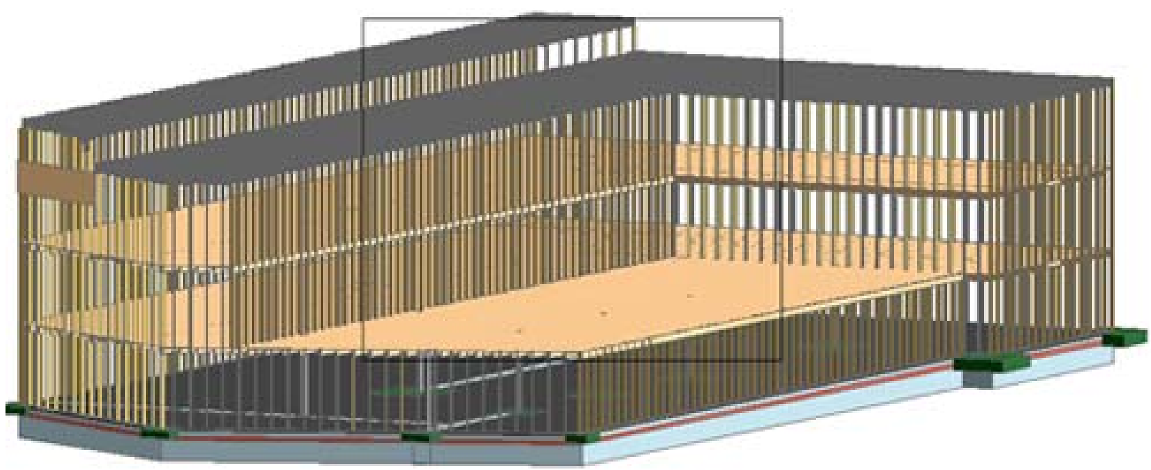

Figure 5: Wood Model (Tobias)