Instruments of Invention and Intent: Evolving Pedagogy for Early Architectural Drawing

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In discipline and practice, architecture works with conventions of perspective and orthographic projection inherited from the Renaissance. Perspective projections produce illusions that simulate vision, orthographic projections set out measurable dimensions that allow three-dimensional buildings to be constructed from scaled two-dimensional drawings. These two modes of projection may seem to be at odds with each other, one emphasizing the art of architecture in qualitative illusory effects, the other emphasizing the technology of architecture in quantitative measure. But of course, many of the most compelling architectural drawings incorporate both the 'art' and 'technology' of architecture. This type of hybrid drawing, that is partly illusionistic and partly measurable,[1] is particularly useful in imagining what a building *could* be without losing track of the measurements of the physical world in which it must exist.

The physical world architects confront today, and how they must measure it, is more complex than ever before. A building, as an assembly of physical parts such as structural members, envelope components, environmental control systems, etc., is much more sophisticated than it was in the Renaissance, the Industrial Revolution, or even twenty years ago. In our era of resource depletion and climate disaster, it is of the utmost importance to understand how this complex assembly of physical parts that make up a building interacts materially and energetically with the larger physical world around it. Visualizing and understanding this material and energetic interaction between a building and the world around it cannot be done by drawing objects alone. It requires tracking the transformation of building components from raw materials extracted from the earth to discrete elements delivered to a site, and their assembly into a building. It requires visualizing how a building, once constructed, will manage flows of energy to create a habitable and comfortable environment for its occupants.

Given these two realities of architecture today – that the discipline relies on Renaissance-era representational techniques, and that practice is dealing with ever increasing complexity in the physical, built world – how should architectural drawing be taught to beginning students? This question might begin to be answered by considering two fundamental aspects of drawing that architects must learn – how to use drawing as an instrument of invention, and how to use it as an instrument of intent that demonstrates or describes the invention it has produced.[2] As they learn to use drawing in both these ways, students become able to explore ideas visually and communicate these ideas to others, including their colleagues, instructors, and eventually the people who will realize the buildings they design. Introducing how drawings are used to invent and describe in this manner, has often been done with exercises that deal with abstract primitive objects. From geometry generated by drawing abstract objects, this type of exercise can reveal nascent architectural conditions such as relationships between interior and exterior, relationships between figure and ground, sequences of spaces, and material thicknesses.

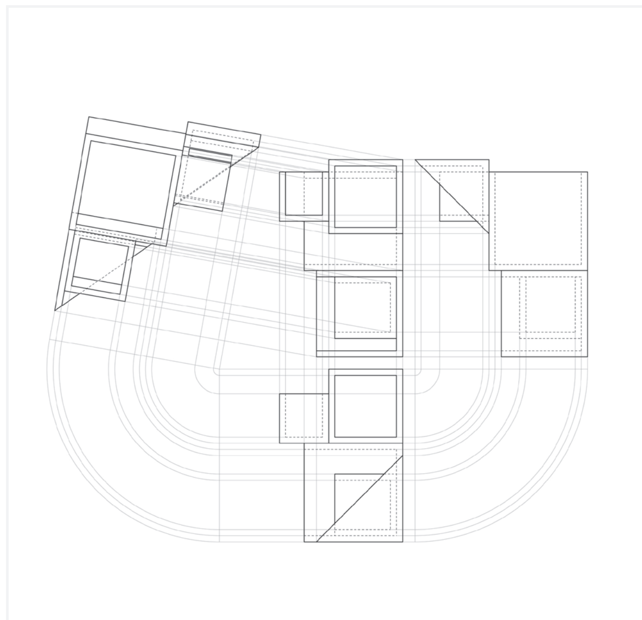

Figure 1. Orthographic projections of nested boxes. Student drawing by Olivia Montolio.

My own work as a visual studies instructor has been an example of this type of drawing exercise that starts with abstract

PROJECT

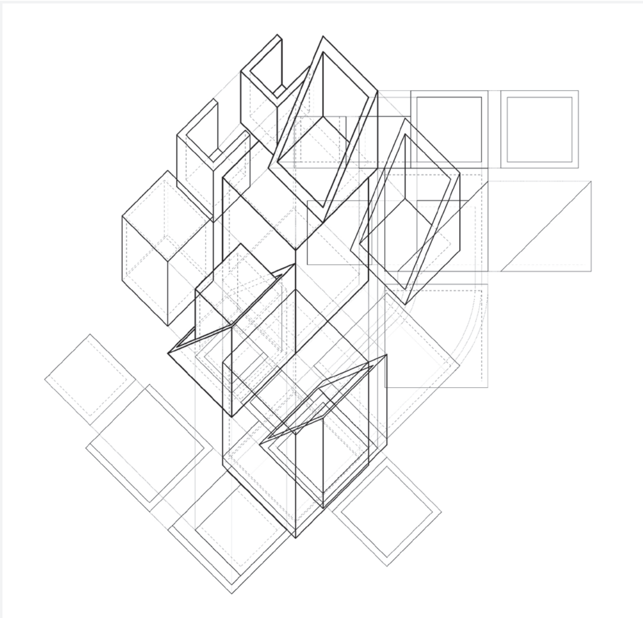

Figure 2. Axonometric projections of nested boxes. Student drawing by Olivia Montolio.

geometry. For a number of years, I have taught a first-year course in which students draw a set of five partially open nested boxes, two of which incorporate an oblique cut. Students are taught to accurately describe the geometry of an assembly of these boxes in measurable multi-view orthographic drawings (figure 1) and axonometric projections (figure 2). Then using their ability to make measured, quantifiable drawings, students are asked to produce more qualitative effects by transforming the boxes with a series of two and three-dimensional drawing operations. The resulting drawings are still measurable, while also incorporating illusory qualities in inventions of form, color, and texture (figure 3). When successful, these drawings suggest novel architectural conditions in terms of relationships between interior and exterior, relationships between figure and ground, sequences of spaces, and material thicknesses.

While this type of drawing exercise effectively addresses a disciplinary concern – it teaches students to use inherited representational conventions to produce drawings that are both measurable and illusory – its shortcoming is that it does not adequately address the increasing complexity of the world of architectural practice, which must be understood as consisting of

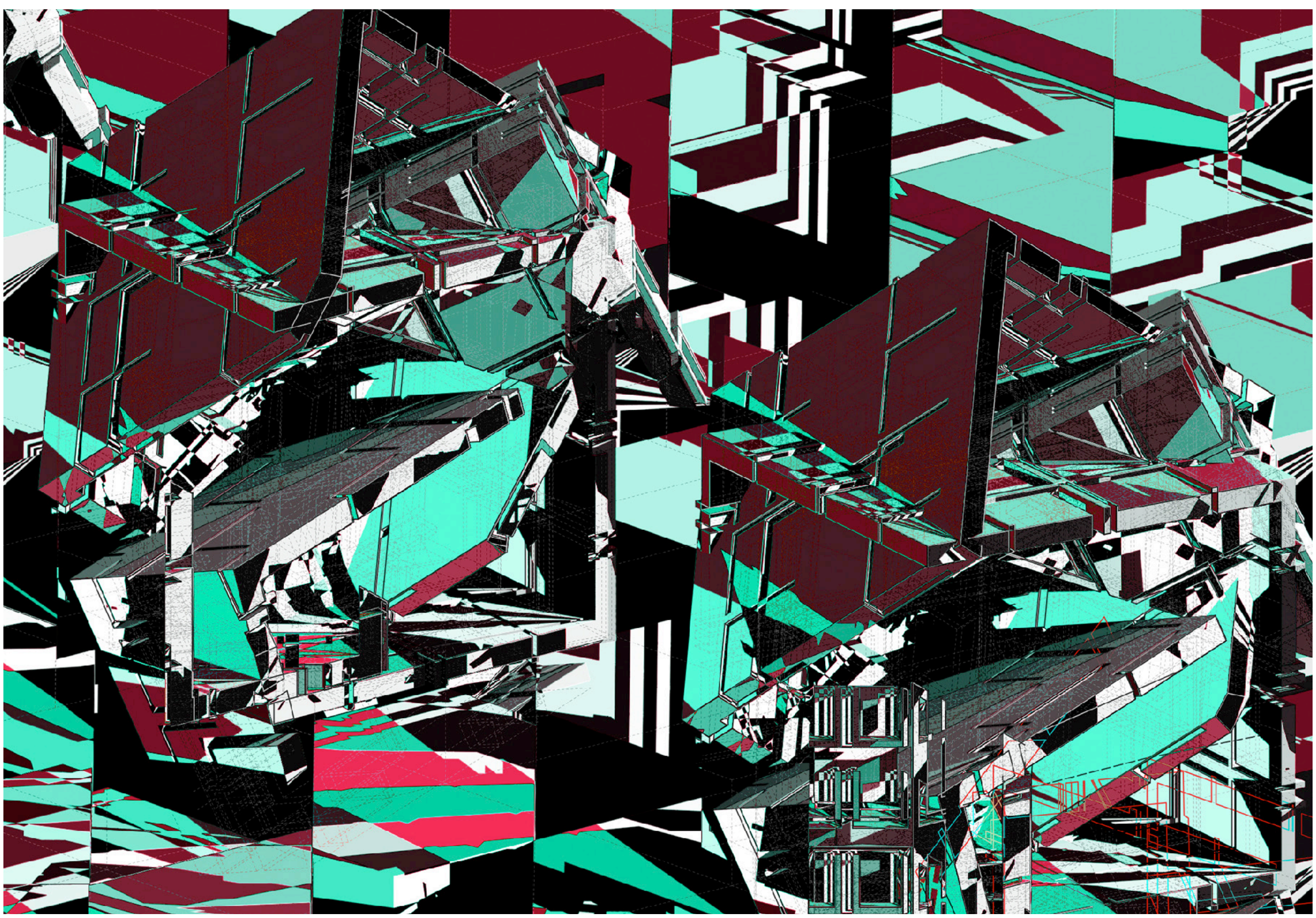

Figure 3. Transformational drawing of nested boxes. Student drawing by Gunnar Thuss.

transformational processes and flows, as much as of objects. As a response, the project presented here is the development of a visual studies course in which the representational skills required to deal with complexities of the built, physical world are more closely tied to the representational skills traditionally considered critical for disciplinary thinking. Rather than a set of abstract boxes, the source drawing object for this evolved version of the course is a household coffee maker (figure 4). The coffee maker can be seen as an analogue for a building in a number of ways: 1) it is an assembly of parts manufactured from raw materials, 2) it contains a sequence of interior spaces, 3) materials and energy flow through it, 4) it creates atmospheric conditions in and around itself.

At the beginning of the course, students will be asked to accurately describe the geometry of the coffee maker in a multi-view orthographic drawing (figure 5). Then they will disassemble the coffee maker, document it photographically as an assembly of parts (figure 6), research the manufacturing processes of its major component materials, make an approximate calculation of the embodied energy and carbon represented by its major

Figure 4. Household coffee maker. Photo by author.

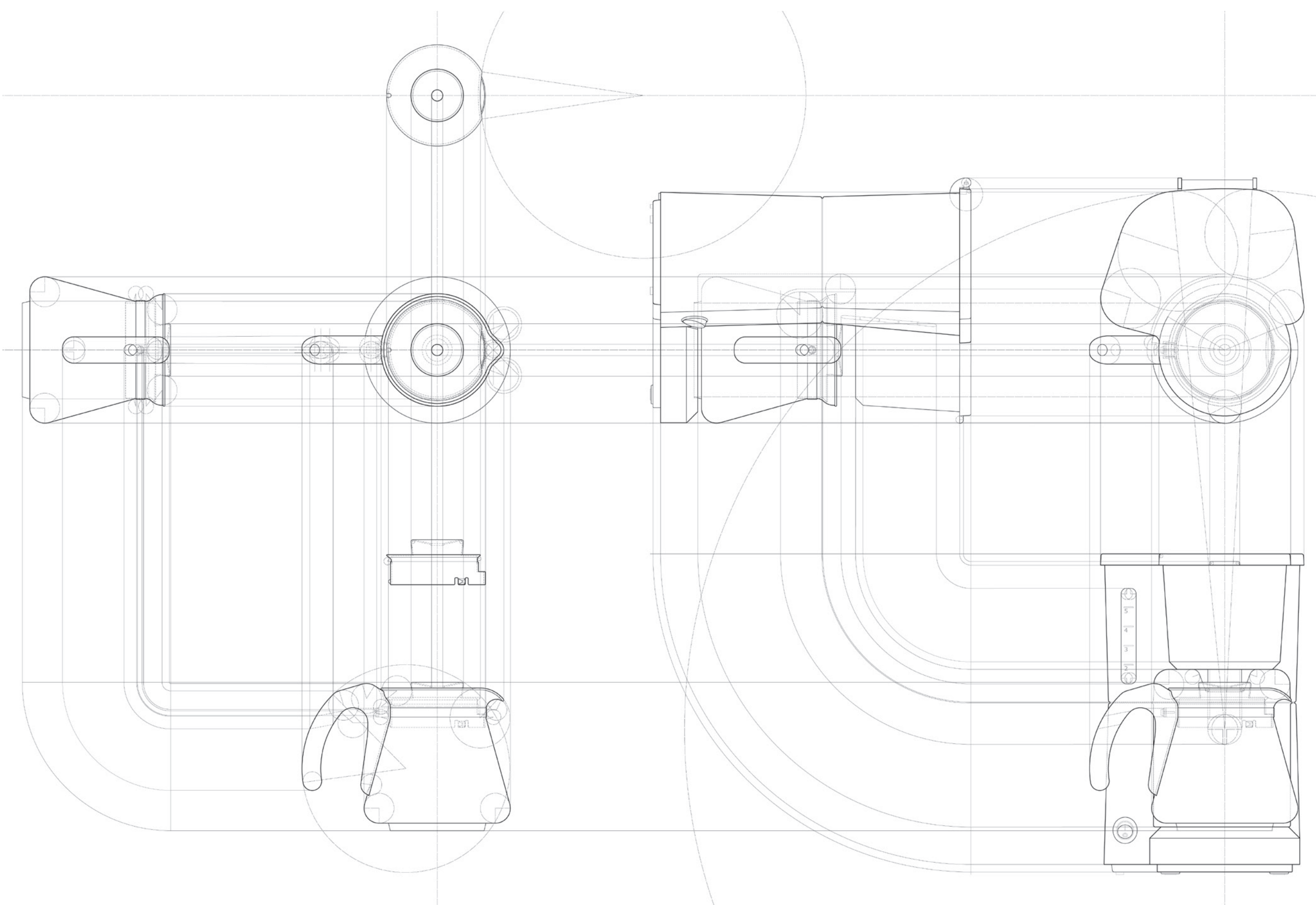

Figure 5. Multi-view orthographic drawing of the coffee maker. Drawing by author.

PROJECT

Figure 6. Disassembled coffee maker. Photo by author.

EMBODIED ENERGY AND CARBON IN MANUFACTURING

Component Materials	Approx. Weight	Raw Materials and Manufacturing Process	Embodied Energy and Carbon/lb	Total Embodied Energy and Carbon
polypropylene plastic	1 lb 8.4 oz	*Plastics are typically manufactured from fossil fuels such as crude oil or natural gas. Fossil fuels are refined to yield different types of hydrocarbons. Complex hydrocarbon atoms are broken down into monomers, then linked in a process call polymerization to form plastic resin. Resins are often processed into pellets which can be reformed into all kinds of plastic shapes.*	*11.3 kWh/lb* *4.43 lb CO^{2}e/lb*	*17.23 kWh* *6.76 lb CO^{2}e*
glass	6.6 oz	*Glass is manufactured by heating sand mixed with limestone, soda ash, and possibly some waste glass collected from recycling, until it melts at approximately 3000° F. As it is heated sand undergoes a chemical transformation into a transparent 'amorphous solid' material, and it retains these qualities as it cools.*	*2.02 kWh/lb* *0.30 lb CO^{2}e/lb*	*0.83 kWh* *0.12 lb CO^{2}e*
aluminum	7.5 oz	*Aluminum is produced from bauxite rock mined from the ground. 4-5 pounds of bauxite are required to produce 1 pound of aluminum. Bauxite ore is refined through the Bayer process, which is used to dissolve and filter out aluminum oxide. Aluminum oxide is further processed through the energy intensive Hall-Héroult process, in which molten aluminum oxide is electrolyzed to produce aluminum metal.*	*25.24 kWh/lb* *6.00 lb CO^{2}e/lb*	*11.83 kWh* *2.81 lb CO^{2}e*
		Notes for comparison: *1. 1 kWh will light a 100W light bulb for 10 hours* *2. burning 1 gallon of gasoline produces 20lb of CO^2*		**TOTAL:** **29.89 kWh** **9.69 lb CO^{2}e**

Figure 7. Analysis of component material manufacturing process, energy consumption, and embodied carbon represented by the coffee maker. Table by author.

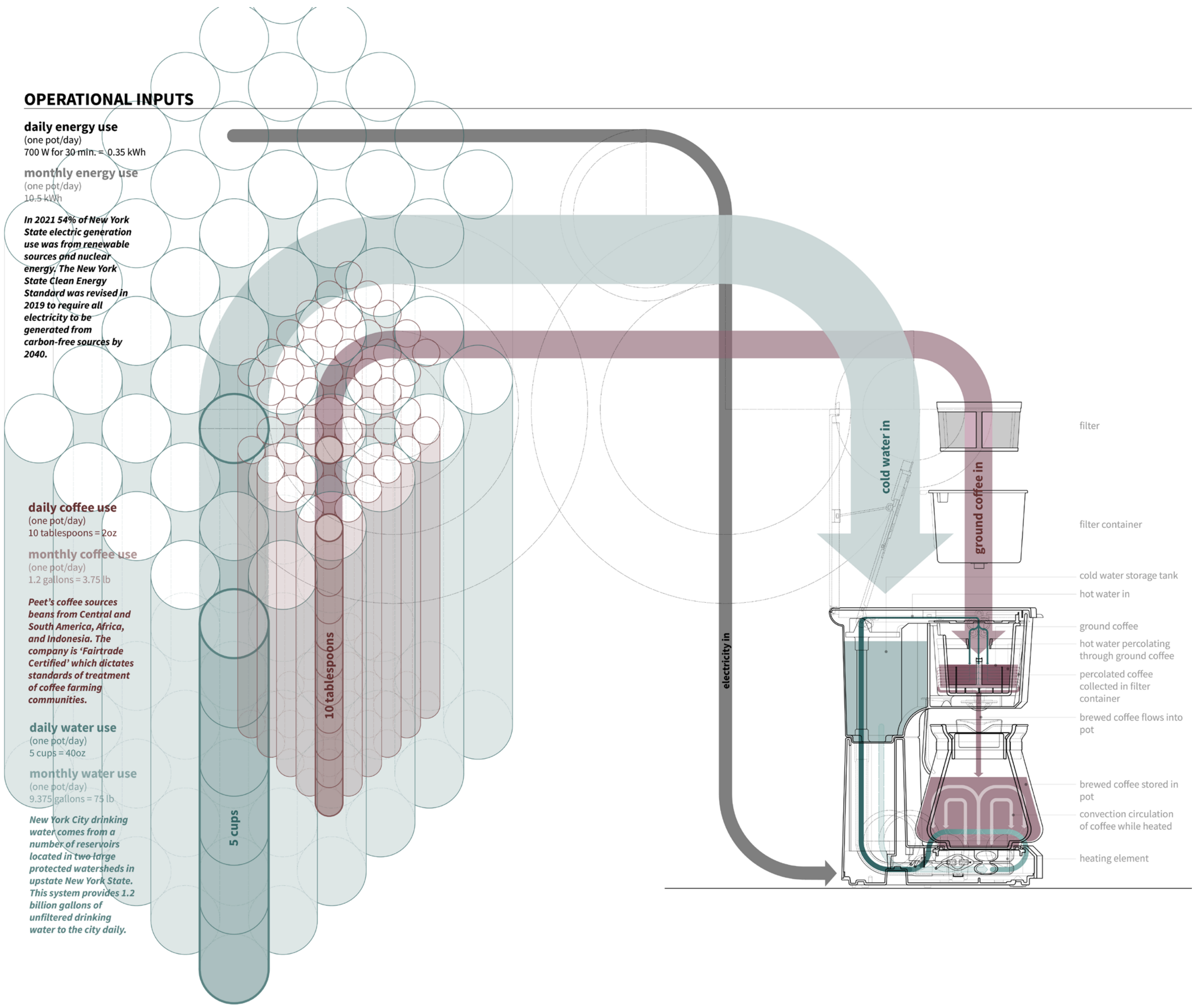

Figure 6. Analysis of materials and energy consumed in operating the coffee maker. Drawing by author.

PROJECT

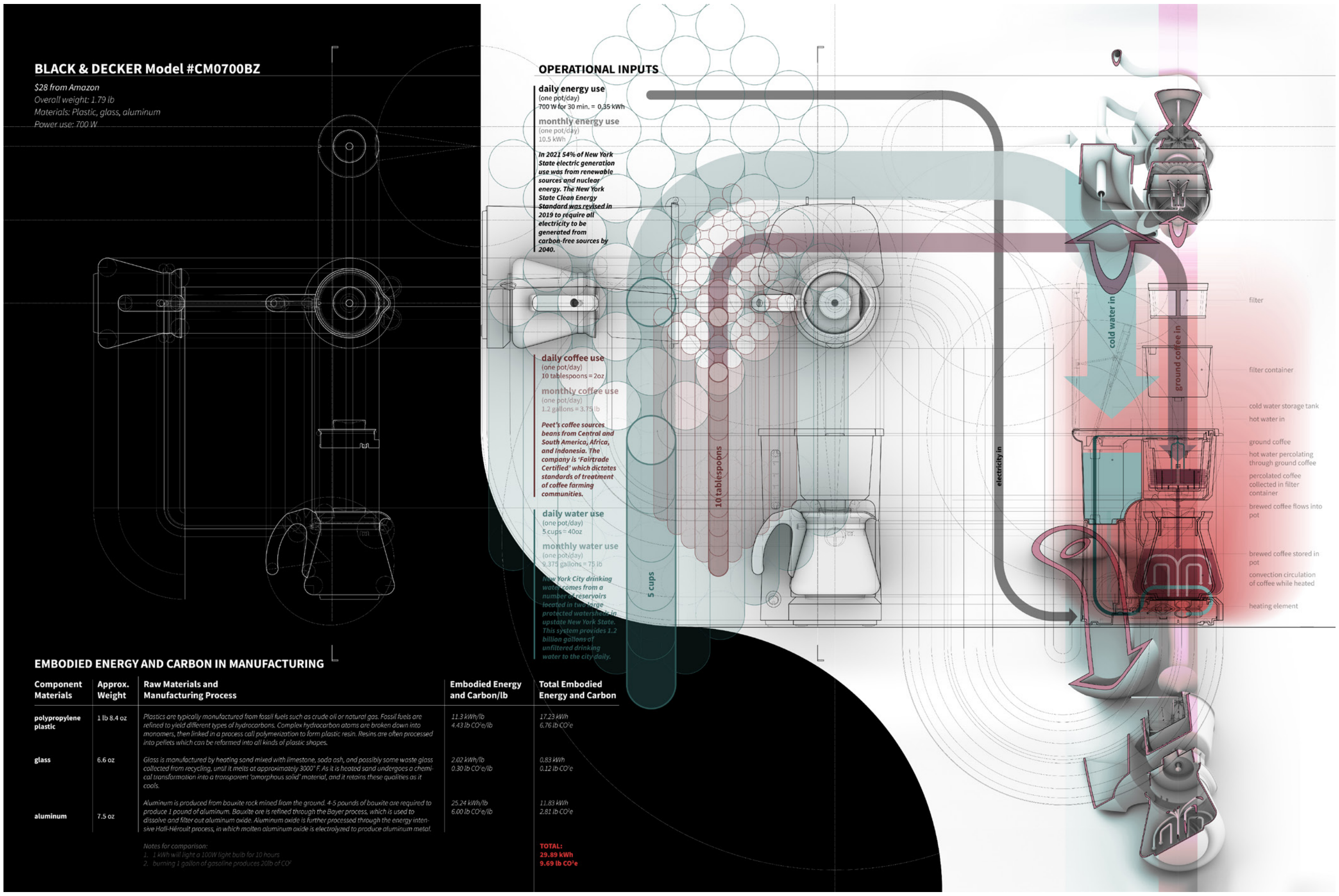

Figure 9. Composite drawing layout of coffee maker. Drawing by author.

component materials (figure 7), and make an approximate calculation of the energy and materials consumed in operating the appliance (figure 8). Inputs for operating the coffee maker will be visualized as volumes and flows, and incorporated with descriptive geometry and material and energy research in a composite drawing layout (figure 9).

The final stage of the course will explore the speculative potential of a representational system that incorporates visualization of materials and energy with objects (figure 10). As with any architectural representation that deals with both the measurable and the illusionistic, there is a shifting distance between the drawing and the contingent reality it might enable. It must mediate a complex transaction between matter, ideas, and the social body.[3] As a mediator between matter, ideas, and the social body, the project shown here is intended to teach students how to use drawings as instruments of invention and intent, which are based on inherited traditions of architectural representation, and also address the increasing complexity of the physical world that architects operate in today.

ENDNOTES

1. Mario Carpo and Frédérique Lemerle, Perspective, Projections & Design: Technologies of Architectural Representation (London: Routledge, 2008), 2-3.
2. Edward Robbins, Why Architects Draw (Cambridge: The MIT Press, 1994) 16.
3. Stan Allen, Practice: Architecture, Technique and Representation (London: Routledge, 2000), 60.

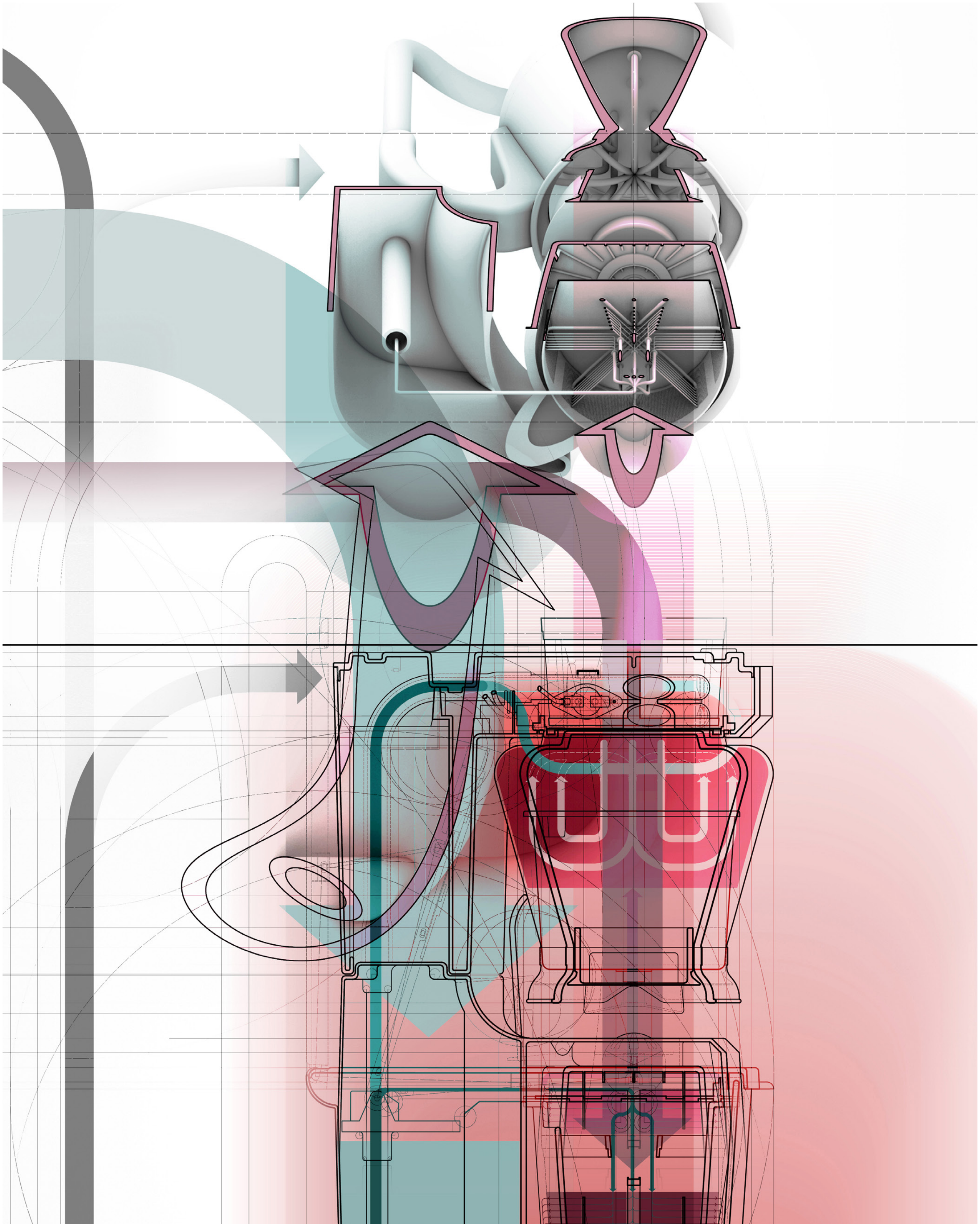

Figure 10. Speculative drawing incorporating visualization of materials and energy with objects. Drawing by author.