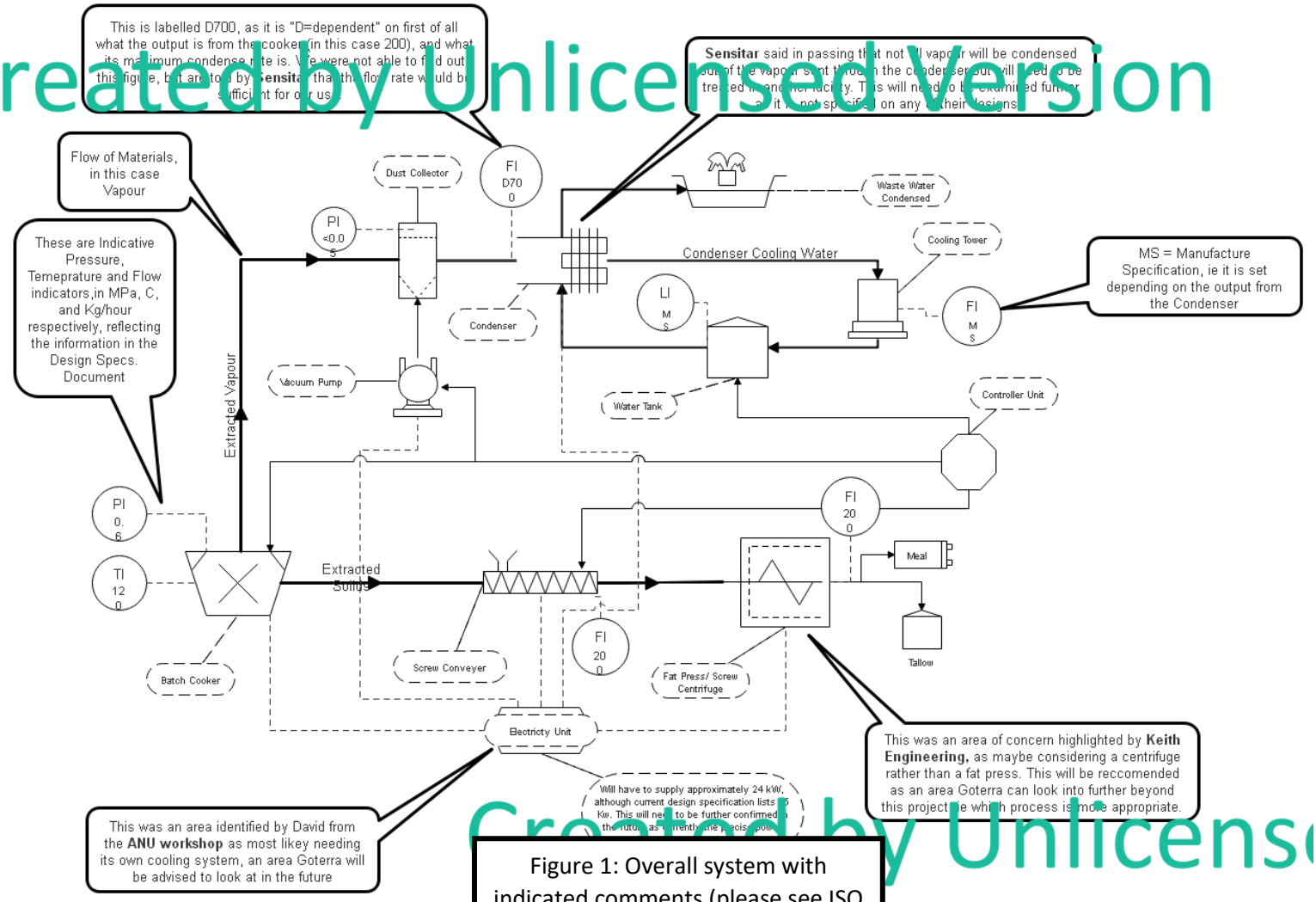

Figure 1: Overall system with indicated comments (please see ISO schematic overview PDF to see these in more detail)

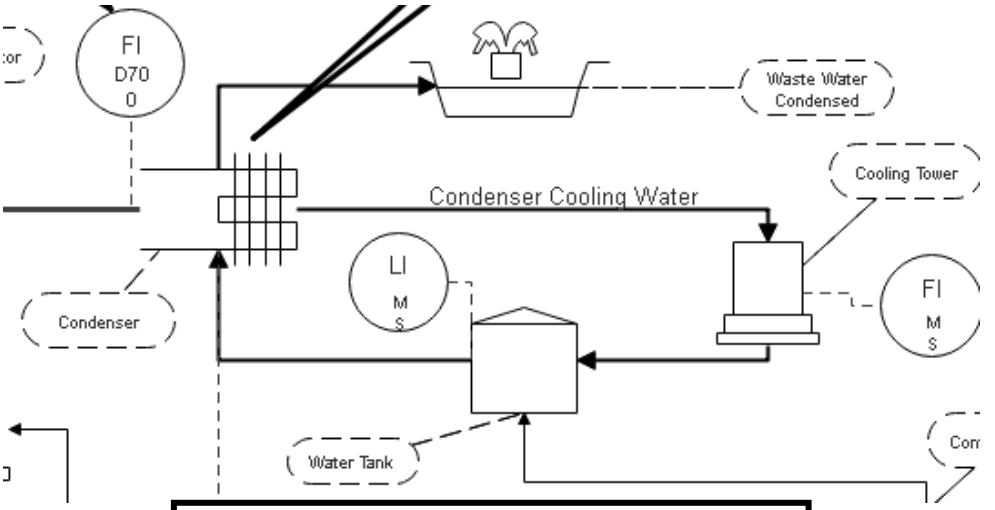

Figure 2: Cooling/condensing System. Water is circulated through tubes in the condenser, allowing vapor to cool, condensing out into waste water to be treated separately

Areas of Uncertainty in the Design:

1. **Lack of Manufacturer Advice Diversity**
    a. After performing the initial research into modern rendering processes in general, and started contacting manufacturers in China with the goal to source specific specifications as to the minimum dimensions possible for each key piece of equipment, we came across the company **Sensitar** who had products that fit our goals quite well. They were also extremely open in helping us understand the rendering process, especially in the smaller scales that we sought. Our communications with them are listed in the repository.
    b. The concern is that reliance on their advice has created a biased design. While there is a wealth of supporting evidence for the above design, including established similar processes, the lack of diversity on advice received may just need to be noted. Other rendering specialists were contacted, but the only reply came from **Keith Engineering**, who needed more details from us to confirm their understanding of the process.
2. **Lack of specifics on some of the rendering processes**
    a. While some of the components shown above have detailed specs on throughput, temperature and pressure values, some we were unable to source. Specifically, those in the cooling system as shown in Figure 2.
    b. For every 1kg of insect material, there is approximately 700g of water and 300g solid material (tallow and meal). Since the throughput and other technical specs of the cooling system is unknown, this may a limiting factor as to how much material can be processed per hour (as the cooling system is what condenses the vapor out of the system).
    c. There is extra equipment needs to be added to this system, as mentioned by Sensitar during the respective meeting. This is because not all the air would be condensed into water in the condenser. Part of the air pass through and condenser would not be condensed. Therefore, the waste air needs to be further processed. One solution given by the manufacturer is adding a washing tower and UV light source to process the waste air. Another solution is using biofilter to process the air.
3. **The areas highlighted by expert feedback**
    a. These are properly outlined in the ISO schematic overview document. While the feedback from Keith Engineering and ANU Workshop was definitely of high value, due to the nature of the project, a preliminary design with strong technical details was only produced in the latter weeks of the semester. This in retrospect greatly inhibited the collection of industry feedback, as contacted companies would request our design but lack enough details to make educated assessments.
4. **Lack of connecting piping and valves**
    a. At the moment, our design makes the assumption that all intermediary components such as pipes and valves can be placed as required.
5. **Waste water is currently untreated**
    a. The condensed vapor is treated as waste water, and needs to be further treated. It unfortunately cannot just flow into normal sewer systems or rivers. This might pose a challenge depending on where the container is placed, and how modular Goterra would like to keep the system.

Recommendations for Future Development:

1. **Redesign of key equipment and processes**
    a. Addressing the concerns above would be the first step in the future development of this project. At the moment, all pieces of equipment can fit inside 2 containers, however the original goal of Goterra was to fit all equipment into a single container. The feasibility of this with current available equipment, sourced through commercial distribution channels does not seem possible, especially so following the traditional rendering techniques as reflected in the design (also with reference to point 5 below). Redesign of some of the pieces of equipment can be explored, such as a smaller cooker, fat press/centrifuge and condenser, however throughput will most likely be reduced (ie the 1 ton every 8 hours figure may be hard to achieve).
2. **Definitively spec the current design**
    a. As mentioned before, the current design is not fully spec'd, in particular the cooling/condensing system in the smaller container. This will need to be rectified by discussing the details with Sensitar in particular, as it is their equipment, we are sourcing, but also possibly explore additional options with other manufacturers.
3. **Seek broader advice on current design**
    a. More oversight on the proposed design would give better insights as to the feasibility of the system. This might be easier to achieve through Goterra's contacts in the rendering industry, as the only way of pulling in potential experts is through contact by email, which is either ignored or enables only superficial dialogue.
4. **Partner with Sensitar for testing**
    a. Sensitar offered verbally to test the black soldier fly larvae in their equipment, this should definitely be followed up upon, as this would allow verification of the appropriateness of the process for the proposed insect material.
5. **Explore options to integrate the design into existing Goterra systems**
    a. As discussed briefly at the last client meeting at Goterra HQ, there is a lot of waste heat that at the moment, is dissipated either in the cookers current cooling processes or when the water is condensed in the cooling system. It may be possible to make use of this excess heat (currently contained in the water circulation system as shown in Figure 2) for other parts of Goterra's insect farming operations.