Aquaculture America '08 – Zebrafish Session

Zebrafish Facility Design and Infrastructure – A Green Perspective

Presentation Notes

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Presenter - Austin Bailey

- I work for the Zebrafish International Resource Center (ZIRC)
    - facility projects, equipment integration, renovations, etc.
- I also work for a NW design firm with a focus on sustainable architecture
    - Rowell Brokaw Architects
- I've been asked to talk about Zebrafish Facility Infrastructure.
    - I'm going to talk about that today through the lens of green design

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- I'm sure you've all heard some of these buzz words floating around - green design, energy efficiency, sustainability, environmental impact.
- Recently the construction and design industries have experienced a boom in green building and a demand for new strategies to address environmental issues.
- These issues are beginning to influence the design of more demanding building types such as laboratories - facilities with significant equipment and infrastructure and also high performance specifications.

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- The environmental issues span from Macro-environment to the Micro-environment.
    - Things such as Energy efficiency, Sit selection, Material use, and even Occupant health.
    - In the case of animal facilities this also includes the health of the model organism
- Aquatic research facilities are not immune to these issues.
    - And each of the above topics can be greatly affected by the design of the aquatic facility
- But today I just have time to talk about one of these.
    - Its possibly the most important for Aquatic Facilities - that is the subject of "Energy Efficiency"

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- So how much of an issue is energy consumption for Aquatic Labs?
- There was an article in the most recent Animal Lab News magazine by Douglas Page that threw out some numbers comparing energy use across building types.
- It was pretty close to comparisons I've seen before. Labs can consume 5-10 times the amount of energy of a typical office building. And animal facilities are on the upper end of that spectrum.

• I wanted to take a closer look at these numbers - so I compared them to some of the buildings we have on the University of Oregon campus. Mind you that these comparisons are each relative to a baseline office building. I found the typical lab number to be right on. A major UO lab consumed about 6 times the amount of energy per sqft of the baseline office complex. (note: the UO comparisons are based solely on electrical consumption.)

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• What surprised me was what I found when I took a look at our aquatic facility.
    - 28 times the amount of electrical energy consumed!
• Why so much demand?

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• Compared to your typical office building:
• Vivaria's demand much larger air handling systems
    - 100% fresh air requirements
    - Aquatics may also have increased cfm to deal with humidity issues
• Aquatics have added water system demands
    - pumps, UV, mechanical filtration, blowers
• Vivaria also have large lighting demands - (ZIRC cycles 14hrs on 10 off) - which extends much beyond a normal office work day. And this happens 7 days a week.
• Beyond the extended lighting schedule - These buildings are always ON. Unlike your house or office which has system down time when you're away, vivaria never turn off. Their systems run continuously.
• So what can we do? - Lets take a look at these systems and see what the potential is here.

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• Lighting Design may be the first option for attacking high energy consumption.
• Typically, lighting for these fish room isn't designed to meet the specific needs of the space - other than a minimal light level at the lowest levels of the racks.
• Surface mounted ceiling fixtures are an inexpensive and commonly used option. They are usually distributed equally across the space (sometimes with regards to rack spacing but this is not always the case).
• Regardless of their spacing this configuration results in a waste of light. Light levels trail off from the source creating a gradient of levels that diminishes as it extends down the face of the rack.
• Light levels must be maintained at a higher overall level to keep minimums within an acceptable range - resulting in an increase in overall energy consumption.
    - This gradient also creates different lighting environments for fish from one location on the rack to another. Which can influence things like algae growth and even fish behavior.

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• Alternatively, lighting fixtures can be selected that wash the face of the rack with even light. Such fixtures are called “wall wash” fixtures and are used commonly for architectural lighting and signage applications.
• A wall wash fixture can be selected to isolate the light distribution to the area of the rack face with minimal overspray.
• And these types of fixtures reflect the light such to minimize hotspots across a surface that gets further and further away, making them ideal for this application.
• What results is a much more even distribution of light from tank to tank. Overall light levels can thus be brought down much closer to desired levels - reducing the overall energy consumption of the lighting scheme.

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• It is also common for the rack lighting (again - commonly flush mounted fixtures) to be used to light not only the rack space but also serve as circulation and task lighting for various zones within the facility. This can also leads to increased energy consumption because lighting levels must be designed to meet the most demanding need.
• Instead, we can design the lighting to meet the specific needs for each of the various zones of the facility.
    - Fish rack lighting that meets standard requirements, Task lighting at work surfaces, Ambient lighting requirements for circulation
• Again these lights are adjusted to provide only the light needed for their specific use - minimizing excess consumption.
• Once the lighting is set up in this manner, you can further adjust the energy consumption levels by adjusting the lighting schedules.
• Fish lighting is on a daily cycle - i.e. 14on:10off - this extends beyond the typical user occupancy patterns
    - During high use periods all the lights may be set for use
    - But during low use times of day, ambient and task lighting zones can be set for motion or manual activation without effecting the rack lighting. And a timed shut off can be used in these locations to further conserve energy.

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• Lets take a look at the other building systems we have in these facilities:
    - Starting with the HVAC (heating, ventilating and air conditioning).
• The main issue with air handling for the facilities is the 100% turn over requirement.- Fresh air is brought into the system, conditioned, supplied to the room, and then exhausted in its entirety to the outside.
    - Compared to most air handling systems which re-circulate the majority of the conditioned air.
• This can be quite a demand on the system in any building. Imagine your energy bill if your home had this requirement.

• On top of this, the air supply for Zebrafish facilities is kept up to 83° in certain cases. Room temp is kept up to maintain a consistent water temp for the fish. An incredible amount of energy is expended heating the air up that extra amount (10°+ over conventional comfort levels).
• There are also other unique factors in play in these facilities. The truth is that in aquatic rooms HVAC is never an isolated system.

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• The water system circulates through the main fish room as well and is ever trying to equilibrate to the air in the room.
• The fish room is the thinnest part of the water system. It functions like the capillaries of our venous system. Its where an incredible amount of exchange happens. Nutrients are supplied, waste is removed. And heat, is transferred.
• Some facilities rely only on room air temperature to maintain water temp. Others have back up water heaters within the aquaculture system itself. But my point here is, that while the HVAC dumps its heat to the outside, its not only energy maintaining air temp that it lost but this also draws heat away from the water as well.
• The truth is, most commonly, the HVAC systems for these building are designed in isolation without consideration for the heat transfer or gain through the water system distribution lines.

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• Centralized water systems are also designed in isolation from other building systems.
• Water consumption is a primary issue with these systems - even for recirculating systems.
    - Daily or weekly water changes can add up. The water changes specified for the initial system are often increased by users for various reasons, resulting in significant water consumption. (again, this water is at 83° and took a lot of energy to heat up).
    - R.O. filtration, which often serves as a makeup water source, consumes much more water than is produced. The waste water usually going directly down the drain.
    - So the effect is twofold. We purge the system of warm water that we have invested energy into and we replace it with cold water that we have to reinvest energy into.
• Then there is energy consumption by the components of the system. Pumps, UV's, Mechanical filtration. These units consume a good deal of energy themselves and these systems run continuously.
• So what do we do about these building systems?
• Of-course, each system itself can become more efficient.
    - Reuse of Wastewater.
        - Good option for R.O. filter waste.

    - Some system waste water will need to be further processed to be used in other locations in the building or site (such as sewage conveyance or irrigation)
- And there are HVAC and water system heat recovery options that can be designed into the systems themselves

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• There is also a concept called integrated systems.
• Its used often in cutting edge green buildings. This is where the mechanical systems are designed in conjunction to support each other and optimize performance beyond that which each system could do on its own. For example: You might have an air return system that pulls room air across the lighting fixtures distributed throughout a space and captures the heat coming off the lamps. This heated air might be used to preheat water lines before they enter a water heating system. The building systems are designed to act as a whole.
• We're starting to see this interdiciplinary approach in animal labs as well. There are certain rodent housing racks, for example, that re-filter the air supplied to the room for animal life support. And building ventilation systems and distribution are being designed specifically to address heat stratification produced by the animal housing systems.
• We know that there are opportunities for the building systems and aquatic systems to be integrated in such a manner. There are Heat Source options to be explored. Heat recovery options - possibly between systems. And there are strategies for minimization of waste and water recovery that are possible.
• The constraints here are that the water system is often viewed as a closed loop - and animal care standards and regulations are dictating cross over potential.
• Existing building code requirements may play into the equation as well.
• And there is the maintenance hurdle. Unlike many other large life support systems, aquatic systems are still be maintained in house. For further integration to occur, institution maintenance staff will have to have the same access (and understanding) that they have in regards to other building systems.

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• Green design is fast becoming a standard in out building culture. And this standard is getting attention from both the public and private sectors for new projects.
• The U.S. Green Building Council has established a rating system for such projects. LEED certification grants credits to projects that meet a variety a environmental design goals. These credits earn a project certification at various award levels.
• LEED certification is becoming integrated into the initial project planning for new laboratory complexes and facilities. Aquatic facilities will ultimately be part of this equation. And it is up to the Aquatics Industry to develop the innovative design and technology to allow our demanding facilities to reach these goals.

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• We have a myriad of environmental issues to consider in the development of great aquatic facilities. But the long term sustainability of a facility rises to the surface. With enough effort invested in the beginning stages of a project, a facility can withstand growth and change while at the same time conserving resources needed for other building/facility infrastructure.

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• I appreciate Mark Francis from Aquaneering for inviting me to be a part of the Zebrafish Session this year at Aquaculture America 08.

• Feel free to contact me with questions or for further information.

- Austin Bailey