RE-IMAGINING EXISTING VACCINE LABS

An industry-wide shift is transforming the vaccine development and manufacturing infrastructure to meet a growing global demand.

The vaccine contract manufacturing market is expected to reach $2.38 billion in 2025, with a 6.5% annual growth rate through 2035. As new vaccines are developed for diseases like tuberculosis, dengue fever, and mpox, laboratory upgrades and renovations are required to support advanced research and production.

Retrofitting existing labs for resiliency and flexibility is a critical priority. While new construction offers the chance to implement the latest technologies, retrofitting preserves the embodied carbon of the original structure and allows for strategic upgrades that reduce environmental impact and improve performance over time.

Resilient design enables facilities to recover quickly and continue operating during disruptions through strategies like elevating backup generators above flood levels, integrating solar power, and incorporating passive heating and cooling systems. By investing in thoughtful, future-ready retrofits, vaccine labs can remain agile, efficient, and aligned with evolving research and production demands without the need for costly overhauls.

EIGHT STRATEGIES FOR ACHIEVING THIS BALANCE

1. Minimizing Disruption During Renovations

Renovating active vaccine labs presents unique challenges, particularly in minimizing disruptions to ongoing research and maintaining safety standards. Labs working with live pathogens or sensitive equipment require stringent environmental controls.

- **Dust Control and Containment**
  - **Containment Barriers:** Robust, sealed, temporary walls made of durable plastic sheeting and sealed doors contain dust and prevent its spread. Negative pressure systems direct airflow away from active spaces.
  - **HEPA Filtration Systems:** Portable HEPA units placed throughout the lab continuously filter air, preventing airborne contaminants from migrating to sensitive areas.
  - **Pre-renovation Surface Cleaning:** Thorough cleaning with HEPA-filtered vacuums removes dust before renovation begins.
  - **Regular Monitoring:** Air quality and dust levels should be monitored throughout the renovation process.
- **Protecting Sensitive Equipment**
  - **Protective Covers:** Sensitive equipment should be covered with dust covers or plastic sheeting. Equipment not in use should be moved to a designated clean area. All equipment in the work area and in adjacent spaces must be monitored, cleaned frequently, or moved to a more appropriate location.
  - **Vibration Isolation:** Shock-absorbing pads and anti-vibration mounts protect equipment from renovation-related vibrations.
- **Maintaining Safety and Security**
  - **Clear Safety Zones:** Establish clearly marked safety zones and restrict access to authorized personnel.
  - **Secure Storage for Hazardous Materials:** Store hazardous materials in designated containment areas.
  - **Real-time Communication:** Constant coordination between the renovation team and lab personnel ensures safety protocols are maintained.

2. Optimizing Energy Efficiency

Energy consumption is a significant operational cost in vaccine labs due to constant temperature, humidity control, and specialized equipment. Retrofitting with energy-efficient upgrades can reduce both operational costs and environmental impact.

- **Energy-Efficient HVAC Systems:** Upgrade HVAC systems with variable air volume (VAV) controls to regulate airflow based on demand, reducing energy consumption.
- **Smart Building Automation:** Integrate a building automation system (BAS) that adjusts energy use based on real-time data, improving energy efficiency. Smart systems can also include air sampling systems which can sample particulates and analyze indoor air quality.
- **LED Lighting and Motion Sensors:** Replacing traditional lighting with LEDs and using motion sensors reduces unnecessary lighting energy consumption.

3. Enhancing Flexibility Through Adaptable Design

Adaptable and modular planning offers flexibility by enabling easy reconfiguration of spaces as needs evolve. In existing labs, modular solutions allow for seamless upgrades or space transformations.

- **Adaptable Workstations:** Movable partitions and reconfigurable workstations can quickly adapt spaces for different research methodologies or production processes.
- **Utility Infrastructure Upgrades:** Upgrade plumbing, electrical, and gas lines to be modular, allowing for flexible reconfigurations as lab needs change.

4. Sustainable Water Management

Water is vital for cleaning, sterilization, and scientific processes in vaccine labs. Retrofitting with water-efficient technologies can conserve resources and reduce operational costs.

- **Closed-Loop Water System:** Reuse water for non-critical functions like cooling or sterilization to reduce consumption.
- **Water-Efficient Fixtures:** Install low-flow faucets and waterless urinals in non-lab spaces to minimize water waste.

5. Retroftting Sustainable Materials

Upgrading materials and finishes in non-critical areas can reduce environmental impact and contribute to a healthier indoor environment.

- **Sustainable Finishes:** Use bamboo or recycled-content vinyl flooring in non-critical areas, reducing carbon footprint. In lab areas, alternative counter materials can provide a more sustainable option. Consider lower VOC paints to reduce off-gassing and improve indoor air quality.
- **Insulation Upgrades:** Improve insulation in walls, roofs, and windows to reduce heating and cooling costs, making labs more adaptable to temperature changes.

6. Enhancing Flexibility Through Adaptable Design

Vaccination labs generate a significant amount of waste. Sustainable waste management strategies include:

- **Waste Segregation Stations:** Improve recycling efforts and encourage proper disposal practices with clearly labeled stations.
- **Sustainable Packaging:** Use reusable or biodegradable packaging to reduce waste.

7. Greening the Lab's Exterior and Landscaping

Sustainable design extends to the exterior of the facility. Strategies to improve environmental performance include:

- **Green Roofs and Urban Gardens:** Green roofs help manage stormwater and reduce heat island effects, while gardens improve biodiversity.
- **PV or Shading strategies:** Adding photovoltaic cells and strategic shading can increase resiliency by providing improved energy access, while shading can extend the usability of outdoor spaces or decrease heat gain in facility interiors.
- **Rainwater Harvesting:** Capture and reuse rainwater for landscaping or non-critical internal functions.

Loyola Medicine
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8. Planning for Future Technology Integration: AI and Data Modeling

AI and advanced data modeling will become increasingly integral to vaccine labs, improving predictive analytics, accelerating vaccine development, and streamlining research. As vaccine research becomes more data-driven, integrating AI will require planning for advanced data infrastructure.

- **Data Rooms and Server Racks:** To support AI, labs will need dedicated spaces for server racks and robust networking systems. This will require retrofitting existing spaces to accommodate more data infrastructure.
- **Increased Power Requirements:** AI technologies demand more electrical capacity, necessitating infrastructure upgrades for higher power feeds, fail-safe systems, and cooling solutions.
- **Cooling Systems:** Enhanced cooling systems, such as precision HVAC units, are needed to prevent overheating from increased server usage.
- **Network Bandwidth:** High-speed networking will be crucial to support the data exchange required for AI models. Ensure sufficient bandwidth and backup systems to avoid delays.

Designing for Resilience

At HED, we work alongside mission-driven organizations to transform legacy spaces into thoughtful, high-performing environments ready for what's next. Whether navigating complex renovations or planning for AI-integrated research, our integrated team thrives in the details and in the big picture.

Let's reimagine what your lab can do—today, and tomorrow.

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