ENVIRONMENTALLY PREFERABLE PURCHASES

GETTING A HANDLE ON "GREEN" PURCHASES FOR YOUR LAB:

HOW TO SELECT AN ENVIRONMENTALLY PREFERABLE CHAMBER AND INCUBATOR

BY: BOB DOTTERER AND LEAH HARRIS

CARON

Opening Doors for Scientists

Selecting an energy efficient chamber or incubator for your lab is a weighty responsibility. There are currently no programs specifically targeted to assist scientists with the assessment of "green" laboratory equipment. The responsibility to identify and purchase environmentally preferable products may seem like a daunting task alone.

We developed this guide to assist with your future chamber and incubator purchases. Our guide begins with a core concept and then delivers an in-depth analysis of the technologies available.

Our core concept is simple in nature: Scientists **deserve** a product that is the **most reliable** and **least costly to operate**. Although this principle was developed for the purpose of purchasing chambers and incubators, the concept is nothing new. There are many other lengthy "green purchasing" guides available by organizations such as the FDA and EPA, but within these guides you will find basic criteria at the root of all green purchasing:

1. Does the product/service in question offer the features, performance and reliability required by my industry?
2. Does the product/service in question offer environmentally friendly technologies that yield cost savings?

One key function of the government-backed EnergyStar program is that it serves as a trusted source that proves products are not only "green," but are also best-in-class. The EnergyStar program has a specific list of criteria a product or appliance must meet. A product or appliance that contributes to significant energy savings but does not offer the features and performance demanded by consumers will not receive the EnergyStar label. Similarly, scientists are not required nor expected to sacrifice product performance for environmental performance. In fact, the FDA places human health and product performance as top priorities in their guide to environmentally preferable purchasing.

Since programs such as EnergyStar have measurable standards for energy-efficient products and appliances, why are there no similar programs in place to label energy efficient laboratory equipment? Labs and the equipment used in labs are complex to assess as a whole because of the many factors that contribute to their energy efficiency or inefficiency. It is not practical to assign one energy efficient "label" to one chamber versus another because the chamber/incubator operation is application based. However, equipment used in labs are far more demanding on natural resources than typical home appliances and there is an opportunity for considerable improvement and environmental sustainability.

If consumers can save $200-$1,100 by replacing a kitchen refrigerator with an EnergyStar certified model, and if a household can save up to 30% on utilities by replacing old appliances with new EnergyStar certified models, then this same logic could be applied to more robust laboratory equipment.

So how do you determine what chamber or incubator is environmentally preferable? Chambers and incubators range from Environmental Chambers, CO_2 Incubators, Refrigerated Incubators, Plant Growth Chambers, Heated Incubators, and so on, and are designed to provide a precisely controlled environment for your research. Although many chambers and incubators appear similar on the outside, the design on the inside is what contributes to the overall efficiency and performance. The crucial design elements that factor overall efficiency in a typical chamber/incubator can include one, some or all of the following systems: Refrigeration, Humidification, Insulation and Airflow. Other additional component factors include the Water Supply/Draining Methods and Interior Lighting.

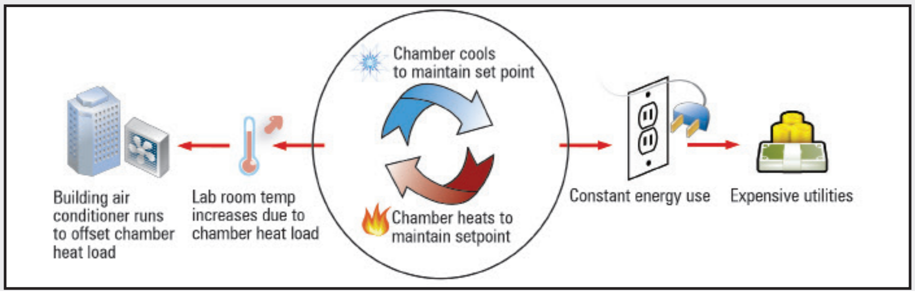
Refrigeration

By their very nature, refrigeration systems are energy intensive, but most GMP and FDA procedures require organizations to perform reliable refrigeration studies on their product. A chamber/incubator that will meet FDA/GMP standards will maintain temperature within ±0.1°C. When labs are testing life saving pharmaceuticals, growing cell cultures, performing food and beverage studies, etc.: There is no room for error.

Chambers and incubators manufactured before 1980 had refrigeration control systems that cycled the refrigeration compressor. A compressor operated in an "on/off" fashion to meet the desired setpoint, but inefficiently over-cooled the interior air below the desired temperature setpoint. The compressor cycled on until a low enough temperature was met. Once met, the compressor was then signaled to shut off until temperature rose enough to trigger a signal to begin cooling again. The process of cooling and heating to meet a desired setpoint thus cycled continuously. On/off refrigeration control methods produced excessive compressor cycling, resulting in very poor efficiency and short compressor life. Additionally, it was a poor method for temperature stability as temperatures would overshoot above and below setpoints.

Improvements were implemented and most manufacturers today utilize a continuous compressor for refrigeration. Continuous refrigeration is a practical choice as the standard for chambers and incubators because it meets the demand for tight and continuous thermal controls. Although this design has greatly improved the life of the compressor and achieves tight stability control, a continuous compressor will always increase the operating cost of the chamber/incubator. Operating efficiency is greatly reduced because the refrigeration system is designed to operate all the time: the refrigeration system runs but does no useful cooling. A setpoint is reached because "heat bucking" is used to offset what cooling is not needed. Obviously, running systems that heat and cool at the same time is a big waste of energy. Additionally, continuous cooling causes the refrigeration system to exhaust heat into the lab, adding more demand on the lab air conditioner.

FIG. 1: CYCLING COMPRESSOR



Thermoelectric cooling is used to cool in economy chambers and incubators. Manufacturers began to offer thermoelectric cooling because it is less costly to service. Thermoelectric cooling, however, only offers temperatures at 20°C below ambient at 60% RH. This method limits the testing capabilities of the chamber, inhibiting the addition of lights or humidity above 60%. Thermoelectric cooling was originally developed for less demanding products and is more suited for smaller non-industrial applications, such as camping coolers and other portable devices, but not the tight demands of scientific equipment.

The ideal refrigeration system for chambers and incubators will meet the demand for tight, continuous, thermal controls by providing the technology demanded by the market, but strategically designed to save resources when possible.

Green Refrigeration on Demand (gROD™) is a refrigeration control that has an intelligence module to determine if refrigeration is needed to maintain temperature setpoint. When needed, the refrigeration system is on and runs continuously, providing excellent stability and long compressor life. If refrigeration is not required, the refrigeration shuts off completely, saving energy and maintaining even longer component life. The refrigeration system either continuously runs or continuously stays off without compromising temperature reliability. gROD determines whether continuous cooling is needed to reach a setpoint based on your setpoint entry, ambient room temperature and chamber load. The intelligent controls can determine if any changes have been made (such as temperature setpoint) to require cooling and immediately adjusts as necessary. No operator intervention is required.

Case study for gROD. FDA ICH, Q1A Guidelines requires pharmaceutical companies to perform:

- Accelerated Testing (40°C, 75% RH) performed at an average ambient at 20°C: gROD would not run refrigeration, saving the customer $648/year and $9,727 during the lifetime of the product. Electricity and HVAC cost savings are calculated into total savings.

- Intermediate Testing (30°C, 60% and 65% RH) performed at an average ambient at 20°C: gROD would not run refrigeration, saving the customer $648/year and $9,727 during the lifetime of the product. Electricity and HVAC cost savings are calculated into total savings.

- Long-term Testing (25°C, 65% RH or 30°C, 65% RH) performed at an average ambient at 20°C: gROD will continuously run refrigeration, giving the scientist reliable temperature control that is required for cooler temperature setpoints.

FIG. 2: REFRIGERATION SYSTEMS OVERVIEW

Feature	Cycling Compressor	Continuous Cooling	Thermoelectric Cooling	Refrigeration on Demand
Reliable	Poor	Excellent	Poor	Excellent
Energy-efficient	Poor	Poor	Good	Excellent
Overall grade	Poor	Good	Fair	EXCELLENT

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Humidification

Moisture, or humidity, is necessary for many lab applications, such as cell culture, pharmaceutical drug studies, industrial testing and more. Controlled humidity is introduced in chambers and incubators by several different methods, all of which have their impact on the overall efficiency of your product.

Steam generated humidity is one traditional method to control chamber/incubator humidity levels. Steam generators consist of a water tank, a water level control device and a heating element. Steam-generated humidity is a process that includes several energy intensive steps that significantly increases the life cycle cost of the chamber or incubator.

Step one: The heating element heats the water. Once water reaches a boiling point, steam rises from the tank and into the chamber, creating moisture, thus elevating the chamber's humidity level.

Step two: Steam has high energy content and is substantially higher in temperature than the chamber is, thus raising the chamber air temperature. If your application requires temperature control, the steam will produce enough heat to place demand on the chamber's refrigeration system.

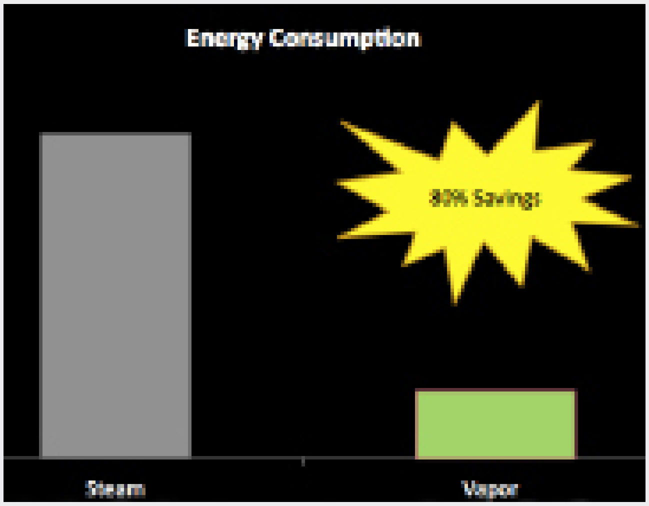
Step three: Condensation, or the removal of humidity from the air, is introduced as a by-product of cooling the air to counteract the heat generated by the steam. Condensation causes the steam generator to work harder to produce the required humidity.

Result: The chamber's components are working in a vicious cycle to maintain the required environmental conditions. The chamber components are causing the chamber itself to set off more heat, placing a greater demand on the lab or building HVAC system.

Everyday chamber/incubator use directly affects the amount of humidity required. For instance, scientists frequently open the incubator door to retrieve cell samples for feeding and harvesting. Humidity is slow to recover to setpoint after door openings in a chamber/incubator with a steam generator. The humidity system is forced to operate each time the door is opened and internal environmental conditions are interrupted. Finally, steam generated humidity creates mineral deposits because heated standing water requires frequent cleaning and replacement of the heating element.

Humidity by vapor atomization is another method for humidification. Atomization is accomplished by forcing water through a tiny orifice, which breaks the water into micron-sized droplets called vapor. Atomization is a controlled process, and only the precise amount of humidity necessary is introduced into the chamber or incubator. This humidity injection method responds quickly to door openings and setpoint changes.

A chamber with humidity control by atomization will require only 20% of the energy to operate versus a chamber with steam generated humidity. Scientists can expect to see an average annual savings of $149 per year and $2,235 during the lifetime of a chamber/incubator that utilizes humidity by vapor atomization versus steam generated humidity.



Feature	Steam Generated Humidity	Humidity by Atomization
Reliable	Poor	Excellent
Energy-efficient	Poor	Excellent
Overall grade	Poor	EXCELLENT

FIG. 3: ENERGY CONSUMPTION COMPARISON
FIG. 4: STEAM GENERATED HUMIDITY VERSUS HUMIDITY BY ATOMIZATION OVERVIEW

Insulation

A strategically insulated chamber or incubator will minimize heat loss, contribute to high thermal retention and tightly control environmental conditions. A strategically insulated chamber simply means that the chamber is designed to minimize internal environmental variations. An all-inclusive insulation strategy will minimize heat loss by incorporating: high-R insulation in the chamber walls, thermally supportive materials at ports or other small openings and a thermally supported chamber door. Many manufactures will place emphasis on defining “insulation” as the actual insulation in the chamber walls, however, if the chamber walls are well insulated but there is nothing designed to minimize heat loss at the door, the efficiency of the insulation is not optimized. Door heaters and door sealing methods greatly impact the efficiency of the chamber. Additionally, incorporating an all-inclusive strategy for minimizing heat loss will reduce the heat load set off by the chamber, and ultimately placing less demand on the building or lab HVAC system.

HERE IS A QUICK INSULATION CHECKLIST

Does the chamber or incubator offer:

- ☐ Quality High-R Insulation in chamber walls
- ☐ Thermally supportive materials at any openings (port, drain, etc.)
- ☐ Sealed Door
- ☐ Door Heaters
- ☐ Triple pane, argon filled, High-R Glass (when applicable)

Airflow

Airflow plays a role in how well air is evenly distributed inside your chamber or incubator. An energy efficient incubator or chamber will have a small motor that requires minimal electricity (<1 Amp) and internal fan to assist the refrigeration system. Proper airflow eliminates hot-spots and ensures temperature uniformity, placing less demand on your chamber or incubator’s refrigeration system and contributing to its overall efficiency. Different types of fan motors have varying energy efficiencies in their ability to circulate air. The most energy efficient motor incorporated in designs today is the PSC (Permanent Split Capacitor) and Variable Speed Motors.

HERE IS A QUICK AIRFLOW CHECKLIST

Does the chamber offer:

- ☐ A PSC or variable speed energy efficient motor?
- ☐ Utilize an internal fan for airflow?

Water Supply and Draining Methods

Chambers and incubators with humidity control need a quality water source (deionized or distilled water) and floor drain. Two methods are utilized for chambers or incubators with humidity control.

Open loop water purification systems are utilized to convert tap water into de-ionized water. Once purified, the de-ionized water is connected to the chamber to supply water for the humidity system. The chamber will produce condensate, and the condensation is collected and eliminated from the chamber and sourced to a floor drain to be removed from the lab. This method is wasteful and an inefficient use of natural resources.

Closed loop water purification goes a step further than traditional water purification systems by providing environmental efficiencies. A closed loop water purification system converts tap water to the proper water purity level for the humidity system and delivers it to the chamber or incubator. Condensation inside the chamber drains back into the water purification system, instead of draining to a floor drain. It is recycled and re-purified. This method is energy efficient because it minimizes water consumption and conserves natural resources.

Lighting

Many chamber and incubator applications require internal lights. Light applications are used for: plant growth, insect growth, day/night studies and other various tests performed to study the effect of light on a product or substance.

<u>LED Lights.</u> LED lights are the most energy efficient light choice. Unfortunately, LED's have an extremely high purchasing cost, do not produce high light intensity and are too directional for many common applications in a chamber or incubator.

<u>Fluorescent lamps.</u> Fluorescent lamps are most commonly used for industrial applications. Many chambers and incubators that were manufactured ten years ago utilized T-12 lamps, but the T-8 lamp is in the process of replacing the T-12. The T-8 lamp is 1 inch in diameter and gives off more light than the T-12, making it more energy efficient.

FIG. 5: WATER PURIFICATION OVERVIEW

Feature	Open Loop Water Purification	Closed Loop Water Purification
Reliable	Excellent	Excellent
Energy-efficient	Poor	Excellent
Overall grade	Good	EXCELLENT

FIG. 6: LIGHTING OVERVIEW

Feature	LED Lights	T-12 Fluorescent Lamps	T-8 Fluorescent Lamps	T-5 Fluorescent Lamps
Reliable	Excellent	Good	Good	Excellent
Energy-efficient	Excellent	Poor	Good	Excellent
Overall grade	EXCELLENT	Fair	Good	EXCELLENT

Although a T-8 lamp is a stride toward a more efficient lamp, some manufacturers incorporate T-5 lamps, which are the most efficient fluorescent lamp for chambers and incubators. T-5 lamps offer high output and are up to 80% brighter and last approximately twice as long as T-8 lamps.

Conclusion

Scientists can evaluate chambers and incubators based on operational designs that yield energy efficiency, such as refrigeration on demand and humidity control by atomization. Scientists can implement measurable change in their labs by understanding how these products are designed and their affect on the environment. Our guide is intended to provide scientists and lab owners or operators the information they need to purchase an energy efficient environmentally controlled chamber or incubator.

The first step toward sustainable labs, and ultimately a more energy independent future, is continued product education and exploration. As you research the purchase of your next chamber or incubator, always remember the key to buying environmentally preferable chambers and incubators: you deserve a product that is the most reliable and least costly to operate.

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About Caron Products

In 2010, Caron Products & Services, Inc. redesigned their entire product line to include green technologies.

Caron chambers and incubators with controlled temperature incorporate gROD™, Refrigeration on Demand, which efficiently manages power consumption and saves electricity. Unlike conventional steam generator humidification systems, Caron's gVapor™ humidity system delivers controlled humidity vapor on an as-needed basis without wasting energy or generating heat.

Our chambers and incubators are designed with energy-efficient components, including high R, CFC-free foam insulation. Units with glass doors are triple pane and argon filled, which meet the Department of Energy standard for refrigerated equipment.

The 115V units will plug into standard laboratory electrical outlets, reducing the amount of energy required to run the chamber.

Caron also manufactures a Condensate Recirculating System, which is a water recycling/purification system to provide a pure water source for a chamber's humidity system. The Condensate Recirculating System will convert tap water into purified water, eliminating the need to purchase more expensive water purification systems or maintain a supply of distilled or deionized water. It connects directly to the chamber and recycles the used water, continuously conditioning it, eliminating the need for a floor drain and conserving natural resources.

To learn more, visit:
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