Terminology: For the purposes of this writing the terms *energy recovery* and *heat recovery* have been used interchangeably as have been the terms *total energy* and *enthalpy.*

Approved Technologies: Energy recovery systems shall utilize proven/approved technologies.

***Simplicity*:** See paragraph entitled *Simplicity* in the *HVAC Systems* section within these *General Guidelines*. Energy recovery equipment and control sequences shall be kept as simple as possible without sacrificing substantial effectiveness. A balance shall be struck between as-designed performance and real-life performance over time. A complex system may yield more attractive up-front performance than a simple system but may consume more energy over its lifespan given that it is more likely to move away from optimal performance over time. Also, complex systems typically require more attention from service personnel (who may not exist). An awareness of these realities shall be maintained during the design process. Designers shall not buckle to pressure to hit energy reduction targets by designing unnecessary complexity into systems.

ASHRAE: Air handling and/or exhaust systems shall incorporate energy recovery capability as required by *ASHRAE Standard 90.1*. Further, application of energy recovery technologies beyond that required to satisfy these requirements is encouraged. Such decisions shall be based upon life cycle cost analysis as developed below.

Life Cycle Cost: It is the policy of the University to make facility design decisions based upon life cycle cost comparison of viable options. Thus, LCC analysis shall be used as a basis for decision making with regard to incorporation of energy recovery systems/equipment beyond that required by *ASHRAE Standard 90.1*. However, true LCCA for University installations is often not as straightforward as it may seem. See paragraph entitled *Life Cycle Cost* within the *HVAC Systems* section within these *General Guidelines* for further development.

Total Energy Recovery: As applied to air systems… Unless inappropriate for a specific application or unachievable within practical limitations, air-to-air heat recovery systems shall be employed. Further, where applicable a total energy recovery system shall be utilized (e.g. enthalpy wheel). It is acknowledged that certain applications are limited to sensible-only heat recovery and total energy recovery is not an option. It is essential that heat recovery system type be identified early in a project prior to space programming to ensure proper location and sizing of equipment rooms and riser shafts given that air-to-air recovery systems require adjacency of outdoor air and exhaust air paths.

Sensible Heat Recovery: In cases where it is inappropriate or impractical to install a total enthalpy heat recovery system, a sensible-only system may be employed. Such systems include the following: plate heat exchangers, heat pipes, sensible wheels and run-around loops. Of these, run-around loops are the least desirable but are typically the only option when outdoor air and associated exhaust air systems are located remotely.

Run-Around Loop: If a run-around loop system is used, it is preferred that it be independent of other heating systems (e.g. preheat system) although the impact on life cycle cost of increased air pressure drop associated with an additional coil shall be considered. If the heat recovery loop incorporates a preheat coil in lieu of an independent heat recovery coil, a booster heat exchanger shall be provided. Options for configuration of run-around loop systems shall be discussed with the Owner prior to development of design.

Combination Systems: Where applicable and supported by LCCA a combination system shall be utilized. This involves the installation of a combination of total and sensible heat recovery devices within a common unit or system. Examples include dedicated outdoor air units and applicable single-zone systems.

Liquid Desiccant Systems: Such systems are currently disallowed based upon complexity and corrosion potential.

Economizer: If a ventilation system equipped with a heat recovery system also incorporates return air (i.e. not a 100% outdoor air unit) an air-side economizer feature shall be provided to accomplish full available “free cooling”.

Bypass: A dampered bypass shall be provided at each air-side heat exchange device that (1) yields high operational pressure drop and (2) is disabled for significant lengths of time. A heat wheel is an obvious example.

Parasitic Losses: It is easy to overlook the energy consumed by adding parasitic losses to a hydronic or ventilation system. Parasitic losses associated with a run-around loop system are among the most apparent.

Pressure Drop: Parasitic losses within a ventilation system in the form of increased air pressure drop must be considered. Failing to do so adequately may result in poor design decision-making. Typically, a substantial pressure drop is associated with energy recovery devices such as heat wheels and heat pipe coils. In some cases such losses can offset a sizable percentage of the apparent energy conserved, especially in cases where effective operating hours of the device are limited. This reality shall always be considered in application of energy reduction systems. Such consideration may result in prudent avoidance or deletion of a particular energy recovery device or system altogether.

Laboratory Exhaust: An energy recovery system shall be utilized in conjunction with all laboratory exhaust airflow. Total energy recovery shall be utilized in conjunction with general lab exhaust. A sensible-only heat recovery system may be utilized in lieu of a total energy wheel for systems containing toxic or noxious fumes but only to the degree required by Code. Applicable codes shall be carefully monitored in anticipation of future approval of heat recovery wheels for such applications. Regardless, a system design that limits cross-contamination of airstreams to an acceptable minimum level shall be employed. This does not necessarily rule out the use of a total energy wheel for such applications. Within this discussion of laboratory exhaust it is acknowledged that heat recovery is inappropriate for certain specialty applications (e.g. perchloric acid exhaust). See section within these *General Guidelines* entitled *Laboratories, Chemical and Biological* for additional treatment of this subject.

Corrosion Resistance: All heat recovery system components exposed to corrosive fumes shall be constructed of appropriate, durable, corrosion resistant materials (e.g. stainless steel, phenolic coatings, ceramic materials, etc.)

Filtration: Filtration shall be provided upstream of each heat recovery device. Each air stream shall be filtered by a minimum of one MERV 8 (30% efficient) filter bank. Filters/housings in contaminated air streams shall be configured such that filters can be changed during system operation without “unloading” filter contents (dust/debris/contaminants) into the air stream and without exposing service personnel to harmful contaminants. (MERV Rating is per *ASHRAE Standard 52.2*. Filter % efficiency is dust spot efficiency rating per *ASHRAE Standard 52.1.)* Exception: Such requirements may be waived by the Owner with the understanding that the exhaust system will be taken out of service for filter replacement.

Cleaning: Provision shall be made for routine cleaning of heat exchange surfaces. Such provision includes incorporation of drain pan(s) for water wash-down as well as isolation/access features as identified above.

Isolation/Access: Each heat recovery device that is located within an air distribution / exhaust air system that is of a critical nature such that continuous operation of the air system is required (e.g. a typical fume exhaust system) shall be configured such that it can be isolated, taken out of service and accessed for cleaning, maintenance or repair while leaving the system in operation. Options include provision of a bypass duct with isolation dampers and provision of N+1 heat recovery devices with isolation capability. Further, such provision shall be configured such that service personnel need not be exposed to contaminated exhaust airflow. This requires that any accessed area be maintained at a positive air pressure relative to any contaminated air stream with which it could potentially communicate. Exception: As with filters, such requirements may be waived by the Owner with the understanding that the exhaust system will be taken out of service for cleaning, maintenance or repair.

Kitchen Exhaust: It is acknowledged that heat recovery devices are typically not installed in kitchen exhaust air streams due to concern about grease fouling. However, in spite of the current norm, consideration shall be given to the application of heat recovery in such systems. Of course, compliance with applicable codes is required.

Heat Recovery Chillers: A limited number of modular heat recovery chillers have been installed on campus. These units generate hot water for building heating while simultaneously generating chilled water for campus cooling. The bottom line is that they have been quite effective at reducing overall heating/cooling energy consumption but have been problematic with regard to operation and maintenance. Thus, the University recommends further development of heat recovery chiller infrastructure via installation of higher quality units. Such quality is typically available in larger size machines only. Thus a multi-building or regional approach is encouraged where possible. It must be pointed out that the total capacity of heat recovery chillers on campus is limited by the minimum (winter) chilled water cooling load served by the central system. Installation of heat recovery chiller systems shall be discussed at length with the Owner prior to further development.