UFS 3-410-01
28 July 2025
Change 1, 23 January 2026

UNIFIED FACILITIES SUPPLEMENT (UFS)

HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS

FOREWORD

Unified Facilities Supplements (UFS) provide non-mandatory, supplemental information in support of Unified Facilities Criteria (UFC). Only UFC establish enforceable criteria. UFS are For Information Only (FIO) and exist to help users understand and apply UFC requirements.

The purpose of UFS is to offer procedural guidance, best practices, lessons learned, examples, and explanatory materials that clarify how to meet UFC criteria. They may include step-by-step procedures, checklists, illustrations, or decision aids, but they do not create new requirements or modify UFC content.

UFS are developed by Discipline Working Groups (DWGs) and published by the Military Services under MIL-STD-3007. Because they are not criteria, they do not require Coordinating Panel (CP) or Engineering Senior Executive Panel (ESEP) approval.

UFS content may be referenced or incorporated into project documents at the discretion of project delivery teams but are not binding unless explicitly included in contract requirements. For Service-specific supplemental guidance, refer to Facilities Supplements (FS).

UNIFIED FACILITIES SUPPLEMENT (UFS)

HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location
1	23 Jan 2023	Added paragraph 2-1 Impact of HVAC System Selection on Energy Compliance; Added paragraph 2-5 Demand Controlled Ventilation (DCV); Added paragraph 2-11 Radiant Heating and Cooling; Added paragraph 2-19 Mechanical Space Size; Added paragraph 2-25 Fan Arrays; Deleted paragraph Design Conditions in 3-2; Added paragraph 3-2.26 Ground Loop Flushing and Purging Connection; Modified paragraphs 2-8.5, 2-10, 2-15, 3-1.1.6, 3-1.2.2, 3-1.2.6, 3-2.2, 3-2.3, 3-2.6, 3-2.12, and 3-2.20

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CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

This UFC Supplement (UFS) provides documentation requirements, commentary, best practices, and other information related to UFC 3-410-01.

1-2 OUTDOOR DESIGN CONDITIONS.

Outdoor design conditions required for heating and cooling load calculations in accordance with UFC 3-410-01 are provided in engineering weather data (EWD) obtained from the 14th Weather Squadron (14 WS) website: https://climate.af.mil/. Follow these steps:

- Use the center drop down menu to select EWD
- Use the right drop down menu to select the site country or state
- Click the Submit button
- On the next screen, select the location
- On the next screen, the EWD is available along with other products available for that site
- The outdoor design conditions are listed on the first page of the EWD under Design Criteria Data.

1-2.1 Retrieving Data.

A common access card is required to access the 14th WS website. Non-common access card users may request EWD from 14 WS if they are working on a DoD contract by following these instructions:

1. Attach a completed Support Assistance Request (SAR) to an email requesting support to 14WS_SAR@us.af.mil. A sample SAR form is in Figure 1-1.
2. This email inbox is monitored Monday through Friday from 0730 to 1630, Eastern Standard Time, except for holidays.
3. Include a complete description of the information being requested including site location and coordinates, a suspense date, a statement about how the data applies to the mission, a military organization point of contact name and phone number, and contract number.
4. The 14 WS will verify that the contractor is working on a valid DoD contract before providing information. After verification, 14 WS will email a portable document format file of the data requested.
5. For climate data that is not for use for DoD projects, contact the National Centers for Environmental Information to purchase the necessary weather data.

1-2.2 Unlisted Sites.

If a site is not included on the 14 WS website, submit a request on the 14 WS “Request Support” page: https://climate.af.mil/sar/. Provide a complete description of the information being requested including the site location and coordinates, a suspense date, a military organization point of contact name and phone number, project contract number (if available), and a statement about how the data applies to the mission.

1-2.3 Additional Information

Additional information regarding 14th Weather Squadron data and potential uses are in the technical guide, Design: Engineering Weather Data, located in related materials on the UFC 3-410-01 webpage.

1-3 COMMENTARY.

Commentary has been provided for content in UFC 3-410-01. The General Design Requirements and IMC Modifications are restated for convenience with the associated commentary with paragraph numbering matching the UFC. Requirements and modifications paragraphs without commentary will not have content and are marked “No Commentary”. Commentary is designated by a “[C]” with the section number repeated and the commentary highlighted in light gray.

1-4 BEST PRACTICES.

The best practices chapter contains information that are not requirements but include background information and best practices based on experience and lessons learned.

1-5 DESIGN ANALYSIS AND DRAWING REQUIREMENTS.

The design analysis and drawing requirements chapter provides documentation requirements necessary to demonstrate compliance with UFC 3-410-01.

1-6 ARMY CENTRALIZED/DECENTRALIZED ENERGY PLANTS.

The Army centralized/decentralized plants chapter provides Army policy for determining the life cycle cost effective approach to planning and design for energy plants including district, islanded, or decentralized plants.

Figure 1-1 SAMPLE SAR FORM

14WS SUPPORT ANALYSIS REQUEST (SAR)

SUBJECT

CONTACT INFORMATION

RANK/TITLE | FULL NAME

TELEPHONE NUMBER | E-MAIL

ORGANIZATION | STATION

ORGANIZATION TYPE: | LOCATION

Are you Meteorological or Oceanographic Personnel? Yes (●) No ( )

Are you a part of the Air Force Weather community? Yes (●) No ( )

REQUEST

When do you need your data?

Describe what you need, include specific locations, if applicable and all pertinent details:

Who will receive the information? What it will be used for? Include any tangible benefits or expected impacts. If classified, contact via classified email.

IF DOD CONTRACTOR
MILITARY POINT OF CONTACT

RANK/TITLE | FULL NAME

CONTACT TELEPHONE | CONTRACT NUMBER

14 WS FORM 1, DEC 17 ***(EF-V3)*** PREVIOUS EDITIONS MAY BE USED. PAGE 1 OF 1 PAGES

CHAPTER 2 BEST PRACTICES

2-1 \1\ IMPACT OF HVAC SYSTEM SELECTION ON ENERGY COMPLIANCE /1/

\1 UFC 1-200-02 and individual service policies require designing buildings to achieve specific energy goals. The following list includes possible HVAC related strategies to consider in support of achieving project energy or resilience goals:

- Transpired solar air collector ventilation preheating systems.
- Energy recovery ventilators (ERVs), with heat exchanger cores, heat pipes, runaround loops, or energy wheels, for projects with or without DOAS units required. Consider additional energy recovery sections for additional savings for projects in areas with extreme outdoor air design temperatures (i.e. 2 heat recovery coils in series, 2 energy wheels in series).
- Reduced temperatures for heating water to allow for higher boiler efficiencies.
- Heat recovery or heat pump chiller systems where low-grade heating water can be utilized.
- Thermal energy storage (TES) systems for areas with high electrical demand rates or other time of day energy implications.*
- Ground-source heat pump systems where heating and cooling loads are of similar magnitude.
- Air-source heat pump systems, with considerations for backup heat sources for cold climates.
- Water-source heat pump systems with ambient loop piping.
- Active chilled beam or passive chilled beam systems.
- Underfloor air distribution (UFAD) systems or displacement ventilation systems.
- Radiant heating and cooling systems.
- Hybrid systems utilizing multiple technologies listed above, or others not listed.

Non-HVAC strategies to consider, which must be coordinated with other design disciplines:

- Solar domestic hot water (SDHW) systems.
- Heat pump domestic hot water heaters.
- Photovoltaic (PV) panel systems.

- Coordinate with architect for increased thermal performance for envelope items (walls, roofs, doors, windows, skylights), and to minimize or eliminate outdoor air infiltration. Consider shading devices or light shelves for exterior windows with high solar heat gains. Consider orientation of exterior walls with extensive glazing for energy usage and prevailing wind direction. Consider ‘green’ roofs or high albedo ‘cool’ roofs.
- Coordinate with electrical engineer for reduction of lighting power and dimming controls beyond code requirements. **/1/**

2-2 OUTDOOR AIR INTAKES.

Locate outdoor air intakes in areas where the potential for air contamination is lowest. Basic guidelines include the following:

- Maximize distance between intakes and cooling towers, plumbing vents, loading docks, and traffic.
- Maintain a minimum distance of 10 meters (30 feet) between intakes and exhausts, more if possible.
- Locate intakes and exhausts on different building faces.

2-3 PURGE MODE.

Where desirable, the designer may incorporate a purge mode into system design. This mode could be used to purge the building with outdoor air during off-hours or to purge an area of the building undergoing maintenance, such as painting.

2-4 COMFORT VENTILATION.

Gravity ventilation is rarely adequate as a reliable source for comfort ventilation. It can be used in high-bay areas that are rarely occupied, such as storage buildings, or in areas that are difficult to ventilate, such as hangars. Consider nighttime air flushing of spaces, multi-speed fans, increased insulation, improved shading, and building site to improve the effectiveness of comfort ventilation.

2-5 \1\ DEMAND CONTROLLED VENTILATION (DCV). /1/

\1 For projects with DOAS units, consider providing VAV boxes or control dampers for ducts serving intermittently occupied spaces, such that outdoor air to space can be reduced or eliminated during periods when spaces are occupied. For Navy projects, mixed air handling units serving intermittently occupied spaces may use CO2 sensors for adjustment of outdoor air during lower or higher occupancy hours than design. **/1/**

2-6 FAN COIL UNITS.

The limitations of fan-coil units with regards to latent loads associated with simply providing adequate ventilation for occupancies such as living quarters make them unsuitable as the only means of cooling and dehumidification in most locations and for most occupancies unless the fan coil unit is equipped with a split coil to allow for the continuous conditioning of outdoor air.

2-7 INDEPENDENT VENTILATION SYSTEMS.

Ventilation systems that are independent of the primary air supply and distribution systems can provide benefits such as increased humidity control, reduced amount of ventilation air than may be otherwise required, and increased equipment operating efficiency.

2-8 DOAS.

Consider using a separate system for outdoor air where necessary to maintain a sensible heat ratio of the mixed air entering the primary air-conditioning unit within the required limits of commercially available equipment and to reduce corrosive, salt-laden air from entering the primary air distribution system.

DOAS, when using specific types and when combined with appropriate HVAC systems, can result in significant energy efficiency.

2-8.1 DOAS Cooling Coil Sizing & Energy Recovery.

Energy recovery devices, when included and operating, reduce the load on the cooling and heating coils in a DOAS. This provides an opportunity to reduce the capacity of the cooling or heating coils, saving money and mitigating potential for excessive cooling/heating system cycling. This comes with a risk that, if the energy recovery device fails or loses effectiveness or air bypasses the device, the coils will not have adequate capacity. Coordinate with the real property owner to determine the preference based on the advantages and risks.

2-8.2 DOAS Heating Mode.

When the majority of spaces need cooling, the DOAS heating mode (not the reheat mode) should discharge air at a condition that maximizes free-cooling to support space cooling operation while avoiding potential for condensation in the space (typically near the supply air distribution devices (diffusers, registers, or grilles) unless the supply condition is otherwise prescribed by the UFC or referenced codes (Example: when supplying at room indoor design condition is required). When the majority of the spaces need heating, the DOAS heating mode should discharge at the design indoor heating space conditions.

2-8.3 DOAS Reheating Mode.

Reheat, at a minimum, should be provided to keep the relative humidity in ventilation supply ductwork below 90% to mitigate potential for mold growth within the duct. Potential for condensation at spaces, typically near supply diffusers, registers, or grilles must also be minimized. When delivering ventilation air directly to spaces, discharge temperatures resulting from cooling or dehumidification at the DOAS can support maintaining required thermal comfort conditions in the space. Reheating beyond what is necessary for duct relative humidity needs is unnecessary and wastes energy. This is reflected in ASHRAE Standard 90.1, HVAC Prescriptive Compliance Path paragraph "Ventilation Air Heating Control."

2-8.4 Distribution Directly to Spaces Versus Through Equipment.

Unless prescribed by the UFC or referenced code, the decision to distribute ventilation air directly to spaces or distributing through equipment depends on the type of HVAC space heating/cooling equipment in the system. When using space or zone level equipment such as fan coil units, zone/space heat pump units, or mini-split units, the equipment fans normally cycle on and off. This is normally preferred for energy saving purposes when using this type of equipment. While the equipment fan is running, distributing ventilation air through the equipment can result in better breathing zone mixing. While cycled off, there is a significant reduction in the ability to mix ventilation air into the breathing zone. To mitigate this, air should be distributed directly to the space rather than passing through the equipment. If equipment fans will run continuously, such as for air handling units serving larger areas of a facility, running ventilation air from the DOAS through this equipment may result in better breathing zone mixing. However, if the equipment is serving multiple zones, this could result in the ventilation rate being higher based on ASHRAE Standard 62.1 calculations and higher energy use than otherwise required. Additionally, control of DOAS leaving air temperature and humidity conditions must be considered in conjunction with any equipment that the DOAS directly supplies air to. The method for delivering ventilation air from a DOAS must be carefully considered.

2-8.5 Low Ventilation Space Distribution Airflows.

Outdoor airflow rates delivered directly to spaces tend to be low. While capture hoods, the typical approach to measuring flow at air distribution devices, can measure low airflow rates (less than 50 cfm (23 lps)), the results can be inaccurate or lack repeatability. Even a tolerance up to +/- 10% could be difficult at very low flows. This may be a consequence of minor instability in the air system resulting from such causes as ambient pressure changes, fan modulation, or damper operation. One method to address this is to keep airflows through air distribution devices no less than a minimum flow. However, the resulting sum of the flow rates could be much higher than the ventilation flow rate necessary, resulting in excessive energy use. Another method to address this issue is to set the design flow rates to deliver the required outdoor airflow, even if low; require the balancer to target the design flow rates; and require duct traverses at key locations to ensure that the sum of the flow delivered to an area is within tolerance. If there is difficulty achieving design flow rate at each air device within tolerance, this may be acceptable if the sum of the airflow delivered to the area, as measured at the duct traverse, is within tolerance. This requires the designer to indicate the traverse locations on the drawings and include language in UFGS 23 05 93 to take measurements at those locations. Another method may be to stabilize flow throughout the system using constant airflow regulators to mitigate instability. **\1** Where constant air flow regulators are used, ensure testing and balancing specifications indicate the requirements for constant airflow regulator balancing separately from standard volume damper balancing. **/1/** Ultimately, it must be understood that special means may be required to achieve repeatable low flow balance.

2-8.6 Space Latent Loads.

Consideration should be given to handling space latent loads using a DOAS. UFC or referenced codes may require this. Space zone sensible cooling systems or light-duty equipment normally operate to maintain space dry-bulb temperature and only incidentally address space humidity when they operate. The equipment in these systems typically cycle cooling on and off, particularly when there are lower sensible loads. Space zone sensible cooling systems can include humidity control which will help to handle space latent loads using strategies such as reducing airflow which depresses cooling coil discharge temperatures; however, the equipment often still cycle cooling off based on dry-bulb temperature conditions. Use of a DOAS to handle latent loads for such spaces provides for continuous space dehumidification, regardless of cycling zone-level equipment, which results in better thermal comfort and mitigating potential for mold growth. This is more of a concern in spaces with low sensible heat ratios.

2-9 ENERGY RECOVERY.

When designing ventilation energy recovery, consider the following:

- Enthalpy Wheel: Wheel exchange material can break off the wheel over time causing air to bypass the energy exchange process
- Fixed Core: There is no concern with exchange material failure and no moving parts. Fixed core devices are generally larger, more reliable, and have less bypass airflow than recovery wheels.

2-10 INFRARED HEATING.

Consider **\1** overhead **/1/** infrared radiant heating for high-bay areas, where spot heating is required, or as permitted by UFC 4-211-01, if applicable.

2-11 \1\ RADIANT HEATING AND COOLING. /1/

\1 Consider in-floor or overhead radiant heating systems or cooling systems for facilities where ventilation air is provided directly to space by central DOAS units. Piping for radiant systems is recommended to be cross-linked polyethylene (PEX), with spacing between pipes as recommended by manufacturer. Consider designing the DOAS to handle room latent loads in these applications. **/1/**

2-12 RELIABILITY.

For Data Processing and Electronic Office areas use two or more smaller units to satisfy the required cooling capacity. This will generally reduce energy consumption at partial cooling loads and will also increase overall system reliability.

2-13 PHOTOCOPIERS & LASER PRINTERS.

If possible, locate photocopiers and laser printers in a separate room or group them together and provide local exhaust. Maintain the separate room at a negative pressure relative to adjacent areas by transferring air from these adjacent areas to the separate room. Do not add the air exhausted from the separate room or local exhaust to the return air or transfer it to any other areas. Coordinate with the architect to place areas requiring negative pressure relative to other spaces in the interior of the building to minimize the chances for negative pressure induced infiltration.

2-14 GROUND SOURCE HEAT PUMP TECHNOLOGIES.

Technologies such as Underground Thermal Energy Storage (UTES) with subsets that include Borehole Thermal Energy Storage (BTES), Aquifer Thermal Energy Storage (ATES), geo-energy piles, or heat exchangers in bodies of water may allow for improved daily and annual load shifting and energy performance. These systems should be coordinated with the AHJ and the real property owner prior to design and implementation. These technologies require more sophisticated modeling and testing during design phase than traditional ground source heat pump systems. Proper testing, modeling, life cycle cost, engineering, maintenance, and environmental considerations must be included in the design process. Suitable geologic formation is a major consideration. The risks associated with increased engineering complexity, high costs installation costs, and the potential for errors must be considered when determining whether to implement these technologies.

2-15 VRF SYSTEMS.

\1 A variable refrigerant flow (VRF) system is defined as any system having digital, centralized control over refrigerant flow rates and system wide control of terminal units and compressors that integrates control over fans, compressors, expansion valves, operational modes, and space conditions. They are heat pump systems in which refrigerant is moved from fan-coil unit to fan-coil unit within the occupied facility spaces. **/1/**

DoD has placed special requirements on these systems due to their inherent risks. Three primary risk areas have been identified: (1) VRF systems currently contain proprietary hardware and software in conflict with 10 USC 2867, (2) VRF systems increase the risk of adverse mission impacts due to EPA leak-rate rules on HFC refrigerant systems and the challenge of locating and repairing a leak in often hard to access areas, and (3) VRF systems have uncertain life-cycle costs (LCC) making comparisons with traditional HVAC systems difficult.

- **Proprietary Systems**: Refer to UFC 3-410-02 for Open Control System Requirements. To our knowledge, all VRF systems currently in production use a proprietary control network and thus fail to meet the requirements of specifications UFGS 25 10 10, UFGS 23 09 00, UFGS 23 09 23.01, and UFGS 23 09 23.02. The adoption and use of systems with proprietary control networks conflicts with the legal requirement of adopting systems with an 'open protocol'. While many VRF systems can connect to a LonWorks or BACnet DDC system through a Gateway device, this does not meet the requirements of an Open system and installation of proprietary networks communicating through a gateway is not permitted by the specifications unless the system meets the specific requirements and approvals for an exception defined in UFC 3-410-02. Further, the facility owner remains dependent upon the original vendor for maintenance and support which also violates the Open system requirements of the specifications.
- **EPA Refrigerant Regulations**: VRF systems have attributes that significantly increase DoD exposure to adverse impacts concerning refrigerant. For instance, VRF systems have refrigerant line lengths much greater than traditional DX systems. These lines extend through the occupied space and are mounted above ceilings and through walls. Tracing and repairing a leak on a VRF system is many times more difficult with an additional access requirement of maintenance crews to the workspace environment. In classified workspaces, shut down of the mission may be necessary to affect repairs.
- **Uncertain Life-Cycle Costs**: There is a lack of information on the rate of component wear to predict replacement intervals. ASHRAE Handbooks show a service life of 15-yrs for DX systems yet, some life-cycle cost studies indicate a VRF expected life of 30-yrs. In addition, the proprietary nature of VRF systems implies a disproportionate reliance on contract repair and proprietary parts versus in-house maintenance.

The DoD will continue to monitor and investigate these risk elements and update the UFC as appropriate.

2-16 CAPACITY OF EQUIPMENT.

Select air conditioning equipment to ensure the minimum anticipated cooling load is larger than the capacity of the lowest stage of the equipment. Use multiple air conditioning units if this is not possible.

2-17 LOCATION OF EXHAUST REGISTERS FOR MOISTURE REMOVAL.

Locate exhaust registers as close as possible to the source of the moisture being exhausted.

2-18 LOCATION OF NEGATIVE PRESSURE SPACES.

Where negative pressure of indoor spaces relative to other indoor spaces is required, consider avoiding placing these spaces on the perimeter of the building to minimize the possibility for negative pressure induced infiltration of the exterior wall cavity. Where placing on the perimeter is unavoidable, ensure that the spaces are negative to the adjacent spaces but not negative to the building exterior.

2-19 \1\ MECHANICAL SPACE SIZE /1/

\1 The size of mechanical room and other mechanical spaces should be based on the systems selected and the size of the equipment and distribution systems and based on accessibility requirements. Mechanical rooms may be smaller when distributed systems are used, such as fan coil units, rather than large central station air handling units. In such cases, additional space above ceiling or in mechanical closets may be necessary. Mechanical room space would still be necessary for distribution equipment. When centralized systems are used, mechanical rooms may need to be larger. There is no appropriate “rule of thumb” for sizing mechanical rooms.

In cold climates, mechanical rooms may need to be larger than typical due to the size of equipment or unique needs. Also consider additional space for temporary emergency heating appliances based on risks associated with heating appliance failures. **/1/**

2-20 DUCT WEATHER AND CORROSION PROTECTION.

Consider the use of double-wall galvanized metal ductwork with UV rated paint for the exterior of buildings for weather protection. In ESC zones C3, C4, and C5, consider the use of stainless-steel ductwork. Connectors, supports, and accessories on exterior applications should be constructed of similar material to the ductwork served. Double wall shop fabricated spiral duct systems with a solid liner for exterior ductwork have fewer joints to seal, a round profile to eliminate ponding, and superior protection for the insulation.

2-21 SOUND AND VIBRATION CONTROL

The UFC limits use of duct silencers and double-wall acoustic duct applications. To mitigate the need for these features, consider the following strategies:

- Ensure fans are sized appropriately with lower tip speeds.
- Locate equipment to avoid sound problems.
- Ensure appropriate vibration isolation and flexible connections are used.
- Consider larger duct sizes to keep velocities lower.
- Consider the use of “Z” transfer duct configurations.
- Use reactive duct silencers or sound attenuators rather than dissipative.

2-22 HYDRONIC SYSTEM FILTRATION.

Automated sub-micron side-stream filters on hydronic systems continuously remove particulates that can cause clogging, fouling, corrosion, and scaling in hydronic systems. This can mitigate associated issues with heat transfer at coils and equipment life. This can be applied for new construction but may be particularly useful in existing building retrofits when the existing hydronic system will be reused.

2-23 VARIABLE SPEED MOTORS AND DRIVES FOR BALANCING.

Consider using variable speed motors or drives for pumps and fans for balancing purposes, even when not necessary for controlling speed in normal operation. Variable speed motors or drives provide a means to balance systems when other practical balancing methods have been exhausted. This can save time in addressing balancing problems. This is generally the only means for balancing direct-drive fans in order to comply with the requirements in ASHRAE 90.1 to minimize throttling losses. Variable speed drives also provide “soft start” capability, extending equipment life. If a variable speed motor or drive is provided for balancing purposes only, this should be indicated in the equipment schedule to avoid confusion relative to the control system requirements.

2-24 TRANSPIRED SOLAR AIR COLLECTORS

Transpired solar air collectors are a passive design strategy to preheat outdoor air. To be effective, the collectors must face the sun (generally south in northern hemisphere and north in southern hemisphere). The energy benefit of transpired solar air collectors can be overestimated when consideration is not given to the conditions under which preheat is appropriate. When used, bypass ducts may be necessary when preheating is not desired. Transpired solar air collectors are often not life cycle cost effective as an energy efficiency measure; although, they may contribute to energy resilience by reducing ventilation heating loads. Due to the shaded area behind the solar collectors, there is potential, particularly in humid areas, for mold to form which may result in introducing higher mold spore counts into the ventilation air.

2-25 \1\ FAN ARRAYS /1/

\1 Fan arrays in air-handling units, consisting of multiple smaller fans in place of a single larger fan, should be considered in design. Where fan arrays are included, refer to the backdraft damper requirements in UFGS 23 30 00. Benefits of fan arrays include:

- Increased redundancy, which can be achieved at a lower construction cost than providing a separate larger fan or air handling unit.
- Decreased air handling unit length, due to reduced installation and clearance requirements for smaller fans versus larger fans.
- Reduced maintenance, as individual smaller fans are typically direct drive rather than belt drive and are lighter and easier to replace than larger fans.

- Possible increased efficiency compared to single fan air handling units in tight mechanical rooms, where fan discharge conditions are not ideal (i.e. straight length of discharge ducts is insufficient).

Drawbacks of fan arrays include:

- Possible decreased efficiency compared to single fan air handling units where adequate straight length of discharge duct is available, with duct approximately the same size as the air handling unit duct connection.
- The incremental air handling unit length reduction benefit is reduced as more fans are incorporated into an array.
- Providing redundancy requires a fan array to be designed such that design airflows are achieved when one fan fails or is in service.
- Fan arrays may increase the cost of air handling units.
- Fan arrays may require additional electrical power requirements.
- Fewer, larger fans in fan arrays can mitigate drawbacks of fan arrays. **/1/**

CHAPTER 3 DESIGN ANALYSIS AND DRAWING REQUIREMENTS

3-1 DESIGN ANALYSIS.

The Design Analysis must consist of a Basis of Design Narrative and Calculations demonstrating compliance with all UFC requirements.

3-1.1 Basis of Design Narrative Requirements.

In addition to the Basis of Design Narrative requirements indicated in UFC 3-401-01, provide the following:

3-1.1.1 Design Conditions.

Provide the interior design conditions, including temperature, humidity, filtration, ventilation, and air changes that are used for the design. Provide a tabulation of the design indoor and outdoor heating and cooling conditions for all occupied and unoccupied areas.

3-1.1.2 Base Utilities.

Describe the source of thermal energy that will be used (Examples: extension of central high-pressure steam, hot water, natural gas, or stand-alone heat source with the type of fuel utilized). Thermal energy source must be determined in compliance with UFC 1-200-02.

3-1.1.3 Sustainable Design.

Briefly describe all energy and water conservation features, systems, and components used in the project and the expected energy savings in accordance with UFC 1-200-02 calculation requirements. Describe all features being used for sustainability credits and include the applicable completed forms.

3-1.1.4 Heating System.

Provide a description of the heating system proposed, including an explanation and cost analysis of why this system is preferred over other alternatives. Indicate locations of major components of the system.

3-1.1.5 Cooling System.

Provide a description of the cooling system proposed including an explanation and cost analysis of why this system is preferred over other alternatives. Indicate locations of major components of the system. Identify special humidification or dehumidification requirements. Indicate ASHRAE Standard filter efficiencies and any other special filtration requirements.

3-1.1.6 Ventilation System.

Provide a brief description of the ventilation system proposed. Indicate the outdoor air ventilation rates in cfm/person (Lps/person) and cfm/ft2 (Lps/m2) for various room types. The prescribed rates must be in compliance with ASHRAE Standard 62.1 or, for residential systems, ASHRAE Standard 62.2. Describe the operation of the ventilation system in **\1** summer/cooling and winter/heating modes. **/1/**

3-1.1.7 HVAC Control System.

Briefly describe the HVAC control system type and its functions. If applicable, indicate a requirement to tie into an existing Base-wide EMCS or UMCS/BAS.

3-1.2 Calculations and Analysis Requirements.

In addition to the calculations and analysis requirements indicated in UFC 3-401-01, provide the following. Identify the source of each calculation including date of reference and chapter, paragraph, or section.

3-1.2.1 Energy Compliance Analysis (ECA).

Provide a Preliminary ECA as required by UFC 3-401-01 and UFC 1-200-02. Provide an updated Final ECA at final submittal.

3-1.2.2 "U" Factor Calculations.

\1\ /1/ Calculate "U" factors, including thermal bridging, for all composite wall and roof systems using the latest edition of ASHRAE *Fundamentals*. Include cross sections drawings of all wall and roof systems to supplement the calculations.

\1 A vapor transmission (hydrothermal) analysis must be provided with either the architectural or mechanical design analysis section in accordance with UFC 3-101-01. **/1/**

3-1.2.3 Heating and Cooling Load Calculations.

Use of professionally-recognized, nationally used computerized load calculating program is required. Load calculations are required for each room or zone by the ASHRAE method indicated in the latest edition of the *Fundamentals Handbook*. Copies of input and output data are required. Provide color-coded zone layout drawing overlaid on floor plan(s) showing how the building was zoned for load calculating program input. Psychrometric calculations of each air-conditioning process must be illustrated on psychrometric charts. Clearly identify all points in the conditioning process on the psychrometric chart and verify the sensible, the latent, and the total cooling capacity using the appropriate data from the chart. Performance requirements must include total cooling capacity, sensible capacity, coil design entering and leaving air conditions (wet and dry-bulb temperatures), design airflow rate, face velocities, coil sensible heat ratio, and entering chill water temperature. Provide a system schematic indicating state point dry-bulb and wet-bulb temperatures (or humidity ratios) of outdoor air, mixed air, supply air, and return airflow streams. Outputs must demonstrate that indoor design conditions are continuously maintained at all outdoor design criteria.

3-1.2.4 Outdoor Air Requirements/Calculations.

Calculate the outdoor air ventilation requirements as prescribed by ASHRAE Standard 62.1. Calculations must consider the factors of “Multiple Spaces,” “Ventilation Effectiveness,” and “Intermittent or Variable Occupancy” as specified in ASHRAE Standard 62.1. Optimize zoning where possible to reduce overall ventilation requirements. Evaluate cost effectiveness of exhaust air and condenser heat recovery. Provide a summary analysis showing compliance with the ventilation requirements. The analysis narrative must document a summary of all factors considered when making design choices regarding IAQ, including alternative ventilation solutions considered and reasons for the selection of the solution chosen. The analysis must also include a room-by-room breakdown of the anticipated or actual number of occupants, the amount of ventilation air required, and any applicable adjustments such as multiple spaces factor, intermittent or variable occupancy factor, the ventilation effectiveness factor, and any other factors such as high relative humidity. For residential buildings, calculate outdoor air ventilation requirements in accordance with ASHRAE Standard 62.2.

3-1.2.5 Building Air Balance and Pressurization Calculations.

Provide air balance and pressurization calculations addressing the relationship between supply, return, outdoor air, relief air, and exhaust air quantities and indicating target pressurization. Individual spaces or area with pressurization requirements must be reflected and referenced in the air balance calculations. Tables must be included that show:

- Each system handling outdoor air and the associated exhaust or relief systems.
    - The amount of outdoor air, relief air, and exhaust air for each set of systems.
    - The differential between outdoor air and relief and exhaust air for each set of systems.
    - For individual spaces with pressurization requirements, show the incoming air volumes (supply and outdoor air) and outgoing air volumes (return, relief, and exhaust air) and the differential.
    - Provide airflow diagrams showing the flows and pressure relationships for the building and spaces with special pressure requirements.

3-1.2.6 Duct Pressure Drop Calculations.

Provide pressure drop calculations for all **\1** supply air, return air, outdoor air, relief air, and exhaust air systems. **/1/**

3-1.2.7 Hydronic System Pressure Drop Calculations.

Provide pressure drop calculations for all supply and return piping systems.

3-1.2.8 Pipe Expansion Calculations.

Provide pipe stress calculations for all low-pressure 15 psig (100 kPa) steam, condensate, and hot water piping systems where the length exceeds 100 linear feet (30m) without a directional change. Provide pipe stress calculations for all medium and high-pressure steam and high temperature hot water systems.

3-1.2.9 Equipment Sizing Calculations.

Provide equipment sizing calculations and psychometric calculations and charts, if applicable, to justify the selection of all equipment, such as the following:

- Terminal equipment including such items as VAV boxes or fan coil units
- Pumps
- Control valves and dampers
- Meters and metering devices
- Fans
- Air Handling Units
- Chillers
- Boilers
- Closed Circuit Coolers and Cooling Towers
- Unitary heating or cooling units
- Energy recovery devices
- Hot Water and Steam Heat Exchangers

3-1.3 Product Data.

Provide manufacturer data for each item on the equipment schedules demonstrating that the performance and features specified are achievable. Include performance data, electrical data, and physical size and weight. Each data sheet must be marked with an identifier that matches the associated equipment schedule identifiers. Unless sole-source or limited-source is approved for the item of equipment, list at least two additional manufacturer’s products (make and model) that meet the design requirements.

3-2 FINAL DRAWING REQUIREMENTS.

In addition to the final drawing requirements indicated in UFC 3-401-01, provide the following:

3-2.1 Site Work.

Show the type and routing of the heat source conveyance system on the drawings. Exterior above and below grade steam and condensate distribution and below grade chilled and hot water distribution plans must be accompanied by profile drawings. Profile drawings must clearly depict all other utilities in the proximity of the new work.

3-2.2 Floor Plans.

Do not show ductwork and piping on the same plan. Single line ductwork layouts are not allowed on final drawings. A **\1** double-line ductwork drawing **/1/** to scale must be provided. Show thermostat locations on the plans with clear indication of associated terminal equipment (as applicable). Show locations of humidistats on floor plans, when required. Show location of door louvers on floor plans or coordinate with architectural drawings. When equipment rooms have interior access in lieu of exterior access, show route for replacement of largest item of equipment including space for a necessary dolly, lift, crane, or other similar transport aids. **\1** Show location of supply duct static pressure sensors for VAV systems. **/1/**

3-2.3 Enlarged Plans.

Provide large-scale details of **\1** mechanical rooms and **/1/** congested areas on the drawings, with dimensions locating all work relative to structural features of the building.

3-2.4 Mechanical Room Plans.

Mechanical rooms must be drawn at no less than ¼” = 1’-0” (1:50). Congested mechanical rooms must be drawn at no less than ½” = 1’-0” (1:20). Mechanical room plans must be supplemented by at least one section; at least two sections for more complex, congested applications. Provide isometric views (3-D) of the mechanical systems in the mechanical rooms showing ductwork, piping, and equipment for designs that include the use of BIM and 3-D modeling.

3-2.5 Schematic Diagrams.

Provide a 3-dimensional isometric diagram representing the mechanical room piping or a 2-dimensional diagram indicating the entire system. Indicate shutoff valve locations to allow replacement of control valves and system components.

\1\ /1/

3-2.6 Equipment Schedules.

Provide an equipment schedule on the drawings indicating actual design conditions, not manufacturer's catalog data. Include as a minimum:

- Airflow quantities (maximum and minimum if applicable) and static pressure requirements. Include notation identifying systems that have air-side diversity (condition in which the sum of maximum airflow to all zones exceeds the maximum airflow capacity of the fan).
- Coil water flow quantities and entering and leaving temperatures.
- Heating and cooling coil sensible and latent capacities including the sensible heat ratio.
- Coil entering and leaving air conditions. For cooling coils include wet-bulb and dry-bulb temperatures at the design flow rate. Ensure these conditions adequately cover the design latent load. For heating coils provide entering and leaving air temperature. Include face velocity for coil selection.
- Coil maximum allowable air side and water side pressure drops.
- Motor electrical characteristics including horsepower, voltage, RPM, and NEMA motor starter size. If variable speed drives are provided for balancing purposes only, indicate such with a note.
- Air distribution device schedule for diffusers, registers, grilles including such information as maximum airflow through each device **\1** type and size, **/1/** service of the device (Examples: supply, return, exhaust, transfer), face size, neck or connection size, maximum noise criteria.

3-2.7 Control Valves Schedule.

Provide flow rates, minimum and maximum Cv, nominal valve size, service (Examples: steam or hot water), configuration (Examples: 2-way or 3-way), and action (Examples: modulating or 2-position).

[C] 3-2.7 Control Valves Schedule.

Minimum Cv is established to avoid cavitation in the control valve. The minimum Cv may be lowered by increasing the system pressure at the pressure regulating valve; however, this must be balanced against allowable operating pressures in the system. A maximum Cv would be used to establish command authority. The control valve must be between these two values.

3-2.8 Metric Valve Coefficient.

The metric version of the valve coefficient, Kv, is calculated in cubic meters per second at 1 kPa pressure drop. Do not use Cv, the English version, on a metric project.

3-2.9 Outdoor Air Schedule.

Provide an outdoor air schedule on the drawings. List the outdoor air to each zone with the number of anticipated or actual occupants. Add a footnote to each schedule indicating that the number of occupants listed is for information purposes only.

3-2.10 Vibration Isolator Schedule.

Where vibration or noise isolation is required, provide a vibration isolator schedule on the drawings indicating type of isolator, application, and deflection in inches (mm).

3-2.11 Fouling Factors.

Indicate fouling factors for all water-to-air and water-to-water heat exchangers (Examples: coils, converters, chillers). Indicate in the appropriate equipment schedule. Fouling factors must be accompanied with their appropriate Inch-Pound or SI units.

3-2.12 Details.

Details must be edited to reflect the configurations and construction materials shown on the plans. **\1** Details must include information on the connection requirements to the building's structural members for equipment, duct, and pipe supports. **/1/**

3-2.13 Access Panels.

Indicate location and size of access panels in floors, walls, and ceilings (except in lay-in tile applications) as required to access valves, smoke dampers, fire dampers, balancing dampers, balancing valves, air vents, drains, duct coils, filters, airflow monitoring stations, equipment, and duct access doors on drawings. Ensure adequate access for servicing, filter replacements, and coil removal. Sufficiently sized, safe access must be provided for the maintenance of valves, variable air volume (VAV) boxes, dampers, controls, and other HVAC components.

3-2.14 Controls Drawings

Refer to UFC 3-410-02 for controls drawings requirements.

3-2.15 Equipment Supports.

Show hanger rods and structural supports for all ceiling or roof-mounted air handling units, heating/ventilating units, fan coil units, exhaust or supply fans, and expansion tanks in drawing details.

3-2.16 Drain Lines.

Show condensate drain lines from equipment such as air handling units or fan coil units. Indicate required depth of water trap. Show slope from drain pan.

3-2.17 Balance Dampers.

All dampers and their intended locations must be clearly delineated on the floor plans.

3-2.18 Ductwork Testing and Construction Classifications.

Indicate those HVAC duct systems to be leak tested on the contract drawings. Provide a completed “Ductwork Construction and Leakage Testing Table” on the drawings indicating duct pressure, seal and leakage classifications, and test pressures for supply air, return air, exhaust air, and outdoor air ductwork, for each piece of air moving equipment on the project. Table 5-1 provides an example of this table. The values in the table are examples; these must be edited for each project.

Table 3-1 Example Ductwork Construction and Leakage Testing Table

Equipment Type	Air System Type	Duct Pressure Classification (in. W.C.)	Seal Class	Leakage Class		Duct Test Pressure (in. W.C.)
				Round/Oval	Rectangular	
Packaged AHU Rooftop - VAV	Supply	4	A	3	4	4.0
	Return	3	A	4	8	3.0
Packaged AHU Rooftop - CV	Supply	2	A	4	8	2.0
	Return	1	A	8	16	1.0
AHU with Economizer	Supply	2	A	4	8	2.0
	Return	1	A	-	16	1.0
	Exhaust	1	A	-	16	1.0
	Outdoor	1	A	8	16	1.0
Series FP VAV Terminal Units	Supply	2	A	4	8	2.0
	Return	1	A	-	8	1.0
Exhaust Fans	Exhaust	1	A	-	16	1.0

Table Notes:

- Test in accordance with UFGS 23 05 93, *Testing, Adjusting, and Balancing for HVAC.*
- Despite *SMACNA HVAC Air Duct Leakage Test Manual*, utilize the duct leakage and seal classes indicated in this table for the listed duct pressure classifications and duct construction types.
- Testing may be done at positive pressure for negative pressure systems.
- All new duct systems must be tested.

3-2.19 Make-up Water.

Detail all accessories, to include pressure reducing valves (PRV), relief valves, and backflow preventers. Show pressure reducing and relief valve pressure settings. Provide separate make-up water piping specialties for chilled and hot water systems.

3-2.20 Flow and Slope Arrows.

Indicate the flow direction of pipe on the **\1** flow diagrams or schematic drawings. Floor plan drawings showing piping do not require flow arrows. **/1/** Show slope direction and rate of slope on all piping systems. Piping systems also include sanitary, steam, compressed air, condensate drain, and any other gravity drained systems.

3-2.21 Guides for Piping.

Show pipe guide locations on all aboveground anchored piping. Route chilled water piping through pipe chases. Route chilled water piping through hallways where feasible. Conceal piping in the walls or ceilings of occupied spaces where it is not feasible to route through pipe chases and hallways. Route chilled water piping in accessible locations to the maximum extent possible for ease of maintenance or replacement.

3-2.22 Pipe Anchors.

Show anchor locations on plans. Provide anchor detail(s).

3-2.23 Pressure Gauges.

Indicate pressure gauge ranges; system operating pressures must be midrange on the graduated scale.

3-2.24 Air Vents.

Show location of air vents required in piping systems.

3-2.25 Balance Valves.

Contract drawings must specify the valve size and flow for each application. When an existing system is modified, provide all information required for re-balancing in the construction documents. Detail installation of all flow control balancing valves.

3-2.26 \1\ Ground Loop Flushing and Purging Connections. /1/

\1 Indicate ground loop flushing and purging flow rate and pressure drop on drawings. **/1/**

3-2.27 Kitchen Hood Diagram.

Provide a detailed air balance diagram on the drawings for every kitchen/dining facility design to show compliance with the ventilation requirements. Indicate required capture velocities and capture distances for all hoods on the drawings. Provide notes and contractor instructions on plans indicating that fan airflows shown for hoods are approximate and requiring the contractor to balance the system to achieve the capture velocities indicated. The scheduled fan and motor size must allow for adjustment of the airflow.

CHAPTER 4 ARMY CENTRALIZED/DECENTRALIZED ENERGY PLANTS

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT CHIEF OF STAFF FOR INSTALLATION MANAGEMENT
600 ARMY PENTAGON
WASHINGTON, DC 20310-0600

DAIM-OD

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: District and Islanded/Decentralized Heating Systems Selection Evaluation with Life Cycle Cost Analysis Guidance

1. Reference: USACE Memorandum, SAB, 18 Dec 2012 (encl).

2. Updated guidance on the selection evaluation process for District and Islanded Decentralized Heating Systems is provided with this memo to assist U.S. Army garrisons and activities in determining the most cost effective lifecycle option for heating solutions. This guidance is the result of a jointly sponsored review funded by ACSIM and executed by USACE.

3. HQ USACE will coordinate with the Air Force and Navy to incorporate the checklist into the existing UFC, Central Heating Plants, UFC 3-430-0SN.

4. Questions regarding the guidance should be directed to Mr. Robert Rizzieri, HQUSACE, 202-761-7769, robert.rizzieri@us.arrny .mil.

FOR THE ASSISTANT CHIEF OF STAFF FOR INSTALLATION MANAGEMENT:

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Encl

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Major General, GS
Director, Operations Directorate

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Evaluation of District and Islanded/Decentralized Utility Options with Life-Cycle Cost Analysis Guidance

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

CEMP-NWD

DEC 18 2012

MEMORANDUM FOR Director of Operations, MG Aycock, Office of the Assistant Chief of Staff for Installation Management (DAIM-OD), 600 Army Pentagon, Washington, DC20310-0600

SUBJECT: District and Islanded/Decentralized Heating Systems selection evaluation with Life Cycle Cost Analysis Guidance

1. This is in response to your request to update technical guidance on "district and islanded/decentralized" heating systems selection resulting from our studies of Joint Base Lewis McCord and Fort Carson. The guidance will help to bring consistency and alignment across the Army.

2. The attached enclosure of the "Evaluation of District and Islanded/Decentralized Utility Options with Life Cycle Cost Analysis Guidance" is ready for distribution. This guidance has been coordinated with Headquarters, Installation Management Command (IMCOM) and your staff, and they are in agreement with its content. We will now commence coordination with the Air Force and Navy to incorporate this checklist into the existing UFC, Central Heating Plants, UFC 3-430-08N.

3. The study that produced the attached checklist concluded that recapitalization of existing central plants in kind are often not the most life-cycle cost effective solution. New technologies, strategies and alternative fuels may result in lower life cycle costs, and efficiency of central plants improves when distribution networks are minimized through denser development and infill of existing sites. Care must be exercised when completing the checklist to ensure that alternatives systems are considered appropriately.

4. Request your office establish policy and distribute to all Landholding Commands. Upon your approval of the policy, USACE will follow through with implementing guidance in the UFC and to our Districts.

5. Questions regarding the interim guidance should be directed to Mr. Robert Rizzieri, HQUSACE, 202-761-7769, Robert.rizzieri@us.army.mil.

Encl

LLOYD C. CALDWELL, P.E.
Director of Military Programs

Evaluation of District and Islanded/Decentralized Utility Options

with Life-Cycle Cost Analysis Guidance

Army Installations are under increasing pressures to ensure capability to meet their designated missions while reducing their overall energy footprint within the local community in a fiscally responsible manner. This guidance is intended to be applied to District and Islanded/Decentralized systems such as District hot water or steam distribution systems, Islanded hot water distribution systems, and District co-generation systems, among others. Definitions of District and Islanded/Decentralized systems can be found at the end of this guidance. This guidance shall be applied to all new construction projects and projects where capital expenditures are being used to replace generation equipment and/or the distribution network for the purpose of rehabilitation. Emergency repairs are excluded from the studies described herein.

1. Evaluations to determine the most cost effective method for delivering utilities to facilities shall follow this decision making process:
    a. Define scope and system requirements
    b. Define alternatives to be considered
    c. Develop Life-Cycle Cost Analysis
    d. Determine most cost effective option

2. Questions to consider when evaluating how utilities will be delivered to facilities include:
    a. Is this a new construction project or project expending capital to replace generation equipment and/or the distribution network for the purpose of rehabilitation?
    b. What fuel sources are available?
    c. What is the required output (heat, hot water, electricity)?
    d. What is the anticipated utility load factor?

3. Evaluations to determine the most cost effective method for delivering utilities to facilities shall comply with the following minimum requirements:
    a. Be completed in the context of the broader Federal and Army energy mandates.
        i. Energy Policy Act of 2005
        ii. Energy Independence and Security Act of 2007
        iii. National Defense Authorization Act
        iv. Office of The Assistant Secretary of the Army for Installations and Environment Strategic Plan
        v. Army Installation Management Community Campaign Plan
        vi. Other: ________________________

    b. Include alternatives to the base case that each meets the defined utility needs using different technologies or bundling of technologies. Although a multi-step transition plan may be used to modernize existing legacy equipment, it is imperative that the alternatives under comparison each meet the defined utility needs. A minimum of three alternatives shall be considered in each study.
        i. Alternative 1 (Base Case): __________________________
        ii. Alternative 2: __________________________
        iii. Alternative 3: __________________________
        iv. Alternative 4: __________________________
        v. Alternative 5: __________________________

Evaluation of District and Islanded/Decentralized Utility Options

with Life-Cycle Cost Analysis Guidance

c. Include a Life-Cycle Cost Analysis (LCCA) which has been conducted for each alternative under consideration. Major LCCA criteria are described in Paragraph 5 and LCCA procedures are described in Paragraph 6.
   i. LCCA Completed by: ___________________________

d. Include sufficient detailed information such that an independent technical review (ITR) can duplicate the results. Assumptions made for the required end state and base and comparison cases shall be clearly identified and documented.
   i. Assumptions have been clearly documented in evaluation

e. Receive an independent technical review (ITR). The ITR shall be a formal review of the study to ensure that planned and completed work complies with predetermined requirements, industry standards, and engineering practices. The ITR team shall be comprised of qualified individuals who have technical expertise applicable to the technologies being studied and shall not have been directly involved in generating the study under review.
   i. USACE is available to support Installations or other Army Offices in validating the qualifications of the ITR team under consideration. Contact HQUSACE, Chief Installation Support, CEMP-CI, at 202-761-5763 for assistance in confirming that the firm or organization being considered to perform the ITR is fully qualified.
   ii. USACE has qualified offices that can perform the described ITRs upon request.
   iii. ITR Conducted by: ___________________________

f. Include a narrative describing which alternative was determined to be most cost effective. This decision will be guided by the results of the LCCA.
   i. Most cost effective option identified and explained

g. Include a narrative describing the appropriate programming course of actions required to implement the recommended alternative. Programming course of action shall consider Army regulations on project programming and work classification.

h. Army shall review new laws and policies to determine if study re-evaluations are warranted. Army and installations shall review mission changes to determine if study re-evaluation is warranted.

4. At a minimum, the following alternatives shall be considered where applicable:
   a. Base case. When there is an existing system the base case alternative shall assume no change to the system.

   b. Completely Decentralized. New or renovated solution that meets individual utility needs of buildings using local, dedicated equipment at each facility. Example: Heating and domestic hot water needs of buildings are met using local dedicated boilers at each facility.

   c. Completely District. New or renovated solution that meets individual utility needs of buildings using one district energy plant (which may or may not include co-generation or tri-generation) with supply and return

Evaluation of District and Islanded/Decentralized Utility Options

with Life-Cycle Cost Analysis Guidance

lines between the buildings and district plant. Example: Heating and domestic hot water needs of buildings are met using a single district heating plant with supply and return lines between the buildings and district heating plant.

d. Island. New or renovated solution that meets individual utility needs of buildings using a combination of decentralized solutions in clusters larger than individual buildings. Example: Heating and domestic hot water needs of buildings are met using a combination of decentralized solutions in clusters larger than individual buildings.

5. The following factors have been determined as having primary influence in LCCA outcomes for provision of building utilities. It is imperative that sound economic and engineering data be developed to support each of the following factors and all calculations and assumptions be clearly documented:
   a. First costs of installation
      i. Capital cost of new equipment: Pricing shall be based on quotations received from manufacturers. Where quotations from manufacturers are not available pricing shall be based on RS Means data. Costs shall be comprehensive and include all components required for a complete and usable system to include distribution network costs.
      ii. Distribution network costs: These are often a significant percentage of capital costs and should be clearly identified for District and Islanded system analyses.
      iii. Labor for installation priced per location: Pricing shall be based on data from recent projects at the Army Installation on projects of comparable scope and scale. Where such projects do not exist pricing shall be based on RS Means data.
   b. Maintenance costs
      i. Required Maintenance: Hours shall be based on manufacturer provided component and system maintenance requirements and life expectancies. If components and/or systems are recommended to be replaced within the 40 year study period the manufacturer's recommendations shall be accounted for in the LCCA.
      ii. Labor Rates: Pricing shall be based on data from existing Army Installation maintenance contracts of comparable scope and scale. Where such contracts do not exist pricing shall be based on RS Means data.
   c. Operations cost
      i. Energy and fuel prices including consideration for interruptible opportunities: Pricing shall be based on current prices experienced at the Installation. Escalation rates shall be determined using the most current version of the Annual Supplement to NIST Handbook 135 and NBS Special Publication 709, titled "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis" and using information from the Department of Energy, Energy Information Administration.
      ii. Energy and fuel used by system: Usage data shall be based on measured use for existing facilities. If measured data does not exist, usage shall be estimated using engineering analysis. For planned projects consumption rates shall be estimated using engineering analysis. Fuel consumption rates shall be obtained from the manufacturer for the life of the equipment being considered. Occupancy schedules and heating/cooling degree days shall be used to determine an average system load factor.

System load factor and equipment fuel consumption rates shall be used to estimate the total fuel consumption and thus the life-cycle cost for fuel use.

iii. Labor for operation priced per location: Pricing shall be based on data from existing Army Installation operation contracts of comparable scope and scale. Where such contracts do not exist pricing shall be based on RS Means data.

Primary Factor	Alternative 1 (Base Case)	Alternative 2 (New, Completely Decentralized)	Alternative 3 (New, Completely District)	Alternative 4 (Hybrid)	Alternative 5 (______)
Capital cost of new equipment ($)					
Capital cost of distribution network ($)					
Labor for installation of new equipment ($)					
Manufacturer recommended maintenance (hours)					
Labor required for maintenance ($)					
Fuel price ($)					
Fuel usage (appropriate units for fuel used)					
Labor required for operations ($)					

d. Note: The factors above are not all inclusive factors for a comprehensive LCCA on provision of building utilities. Additional factors identified in NIST Handbook 135 which shall be considered in the LCCA include but are not limited to the following:

i. Renovation and demolition costs: Pricing shall be based on data from recent projects at the Army Installation on projects of comparable scope and scale. Where such projects do not exist pricing shall be based on RS Means data.

ii. Costs for water treatment: Pricing shall be based on data from recent projects at the Army Installation on projects of comparable scope and scale. Where such projects do not exist pricing shall be based on RS Means data.

Evaluation of District and Islanded/Decentralized Utility Options

with Life-Cycle Cost Analysis Guidance

iii. Costs associated with concurrent applicable projects: Ensure cost savings associated with concurrent projects that open roads, trenches, or accomplish other projects that would support the alternative under consideration are adequately captured.
iv. Requirements for equipment redundancy: Costs shall be included when backup equipment is required to meet statutory standby requirements (Example: generator for critical hospital loads).
v. Salvage value at end of useful life: Pricing shall be based on data from recent projects at the Army Installation on projects of comparable scope and scale. Where such projects do not exist pricing shall be based on RS Means data.

6. The Life-Cycle Cost Analysis identified above shall be conducted in accordance with the most current version of the National Institute of Standards and Technology (NIST) Handbook 135, "Life-Cycle Costing Manual for the Federal Energy Management Program", associated supplements and U.S. Army Corps of Engineers Engineering and Construction Bulletin 2012-13, "Energy Implementation Guidance Update, ASHRAE 189.1, Life-Cycle Cost Analysis Requirements". The study period shall be set at 40 years. Final LCCA documentation shall include a comprehensive summary that defines each alternative considered with assumptions and references provided for each parameter; the assumptions shall be clear and of a level of detail sufficient to be used by a third party to duplicate the results of the LCCA. LCCAs shall be completed using the same matrix of information consistently across alternatives to ensure a fair comparison is made between alternatives. For example, building loads and cost of fuel shall be consistent between base and alternatives.
   a. LCCA complies with NIST Handbook 135
   b. LCCA study period set at 40 years
   c. Comprehensive summary defining alternatives considered with assumptions and references for each parameter is provided
   d. Alternatives use same matrix of information
   e. LCCA for each alternative reflects all costs associated with meeting the identified long term energy goals

7. The alternative whose LCCA has the lowest life cycle cost is considered the most cost effective solution. Further guidance on analyzing the results of LCCAs can be found in NIST Handbook 135.

8. Definitions
   a. **District System**. A community scale utility system connecting multiple users through a distribution network that provides heating, domestic hot water, and/or electricity to facilities.

   b. **Islanded/Decentralized System**. A utility system for providing heating, domestic hot water, and/or electricity to one or more co-located buildings at or near the point of use with a limited distribution network.