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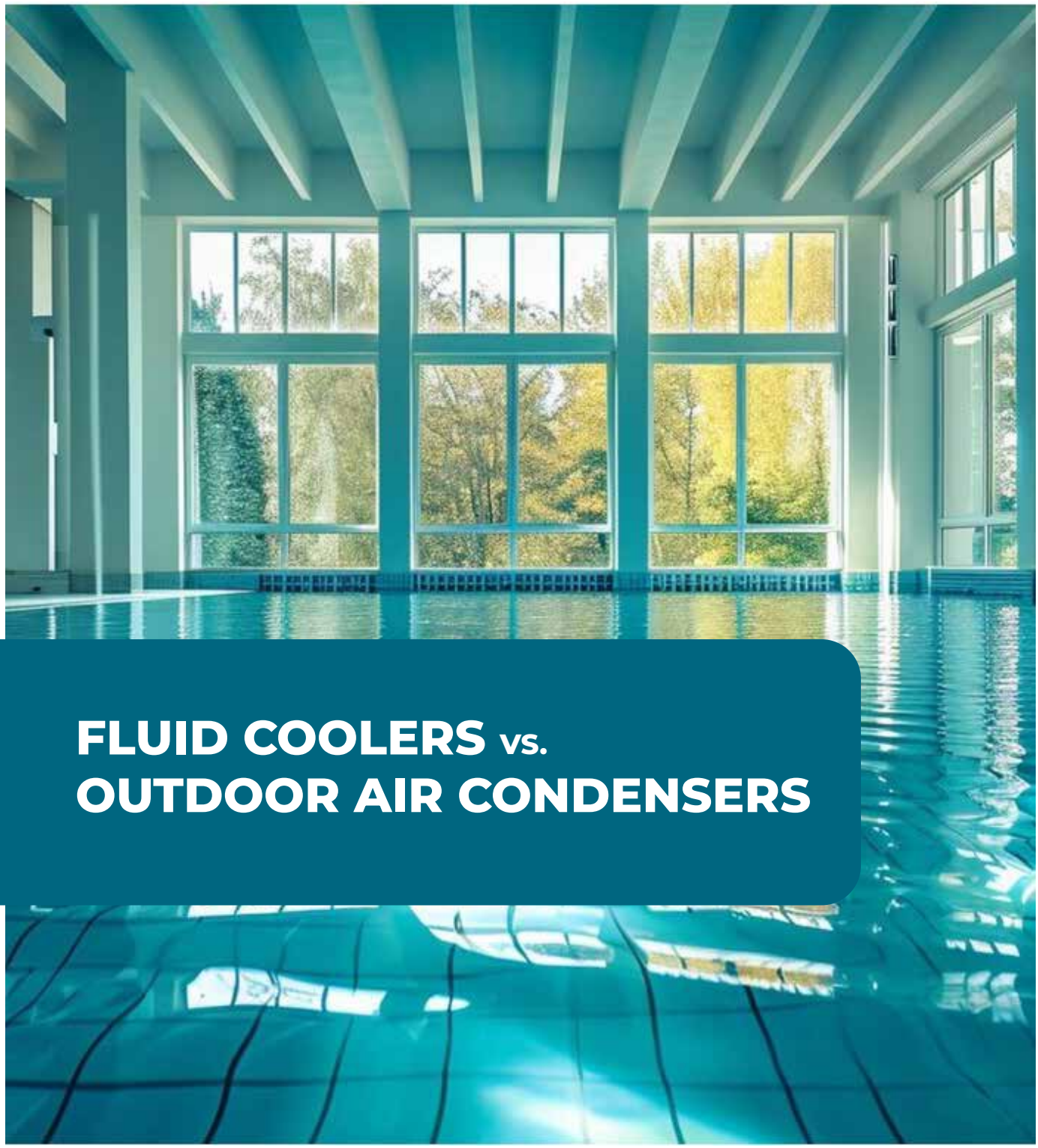

FLUID COOLERS vs. OUTDOOR AIR CONDENSERS

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I- Executive Summary

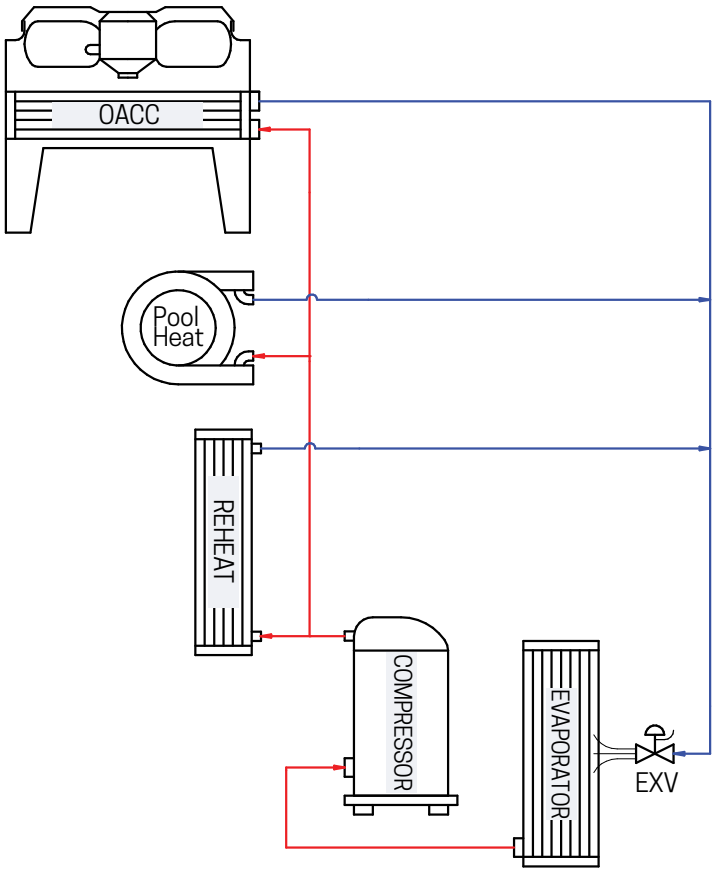
Fluid-cooled systems have become the global standard in HVAC due to their reliability and longevity. This technology has been available from all manufacturers for decades. The push for electrification, clean energy and reduced carbon and greenhouse gas emissions has further accelerated the adoption of fluid-cooling technologies.

In this article, we compare fluid-cooled systems that utilize fluid coolers (also known as dry coolers, or water-cooled systems) against traditional split DX systems that use outdoor air condensers (also known as refrigerant condensers, remote condensers, air-cooled systems, or refrigerant-based systems)

Key Takeaways:

- **Total Cost of Ownership:** going fluid-cooled saves $105,670 over the lifespan of your dehumidifier with a 2-year and 4-month payback period (refer to table page 7).
  - Note: These figures are based on a median refrigerant cost of $50/lb. Due to market volatility observed in May 2025, prices have surged to as high as $175/lb, potentially increasing the lifetime cost savings of fluid-cooled systems to over $258,970 (refer to table page 8).
- **First Cost:** fluid cooler net installed cost is similar to that of outdoor air condensers when piping and field refrigerant charging costs are considered (refer to table page 7).
- **Reliability:** a split DX system using outdoor air condensers and hot gas reheat coils introduces an extra ~4000ft of thin copper piping and 100s of brazed return bends, resulting in 300% leakage rate compared to fluid cooled systems.
- **Longevity:** ASHRAE benchmarks water-cooled equipment to last 30% longer than air-cooled equipment[6], while manufacturers and contractors have seen examples of water-cooled equipment lasting as much as twice as long as air-cooled equivalents.
- **Compliance:** governing rules and regulations surrounding refrigerant charge means more work for owners to document and report on air-cooled equipment performance.
- **Location Limitations:** outdoor air condensers are generally limited to a 50ft line length, whereas fluid coolers can be placed as far or as close to the equipment as needed.

II- Outdoor Air Condenser Operation

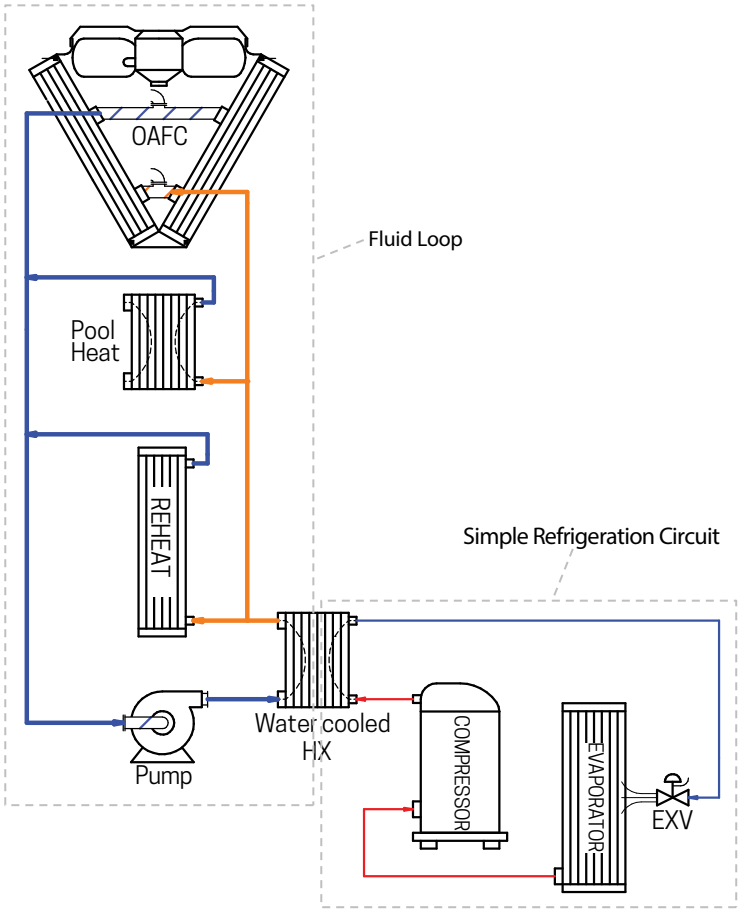


An outdoor air condenser sends refrigerant directly outside, where it is cooled and condensed by the outdoor air before returning indoors to absorb more heat.

These systems use a massive refrigerant charge, and reject heat to three places: pool water, pool room air and outdoors for AC. Split DX systems will have three condensers (reheat coil, AC coil and pool water heater) of which one is always idle. Idle condensers will fill up with refrigerant and compressor oil. The bigger the charge, the more critical it is to manage using refrigeration specialties: oversized receivers, oil separators and suction accumulators.

Additionally, multi-compressor units have multiple sets of copper pipes run to the OACC, doubling and tripling the risk of leaks that are hard to find before all the refrigerant has leaked out. This is in stark contrast to single PVC pipe set sending glycol to fluid coolers, which creates a hard to miss puddle should there be a leak.

III- Fluid/Dry Cooler Operation



Fluid cooled systems have significantly lower refrigerant charges and as a result dramatically reduce carbon emissions. The principle is simple: liquid is a more efficient heat transfer medium than air, allowing the system to operate at lower temperatures and reducing the workload on the compressor. This results in lower energy consumption as well as longer compressor lifespans.

These systems also offer several advantages including: better cooling performance in hot climates, smaller footprint, quieter operation, and lower long-term maintenance costs compared to air-cooled systems.

A fluid-cooled unit has the potential of leveraging a fluid-cooled fully modulating reheat coil for precise reheat control, such as the one manufactured by PoolPak. By stabilizing the space temperature, relative humidity is naturally stabilized, whereas DX systems are on/off and artificially create temperature and relative humidity swings.

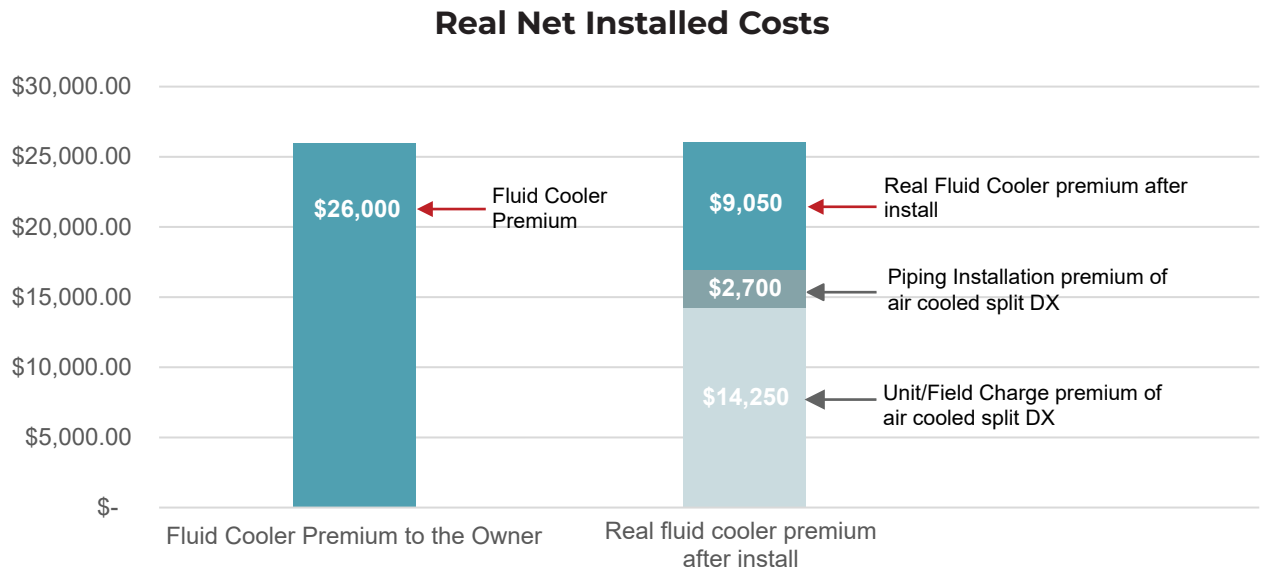
One fluid-cooled heat rejection option is a dry cooler, which sends a hot fluid, which has already condensed the refrigerant inside the unit, outside to be cooled. This fluid is then circulated back into the system to continue the cooling cycle.
Fluid-cooled systems can also reject heat to geothermal loops or cooling towers.

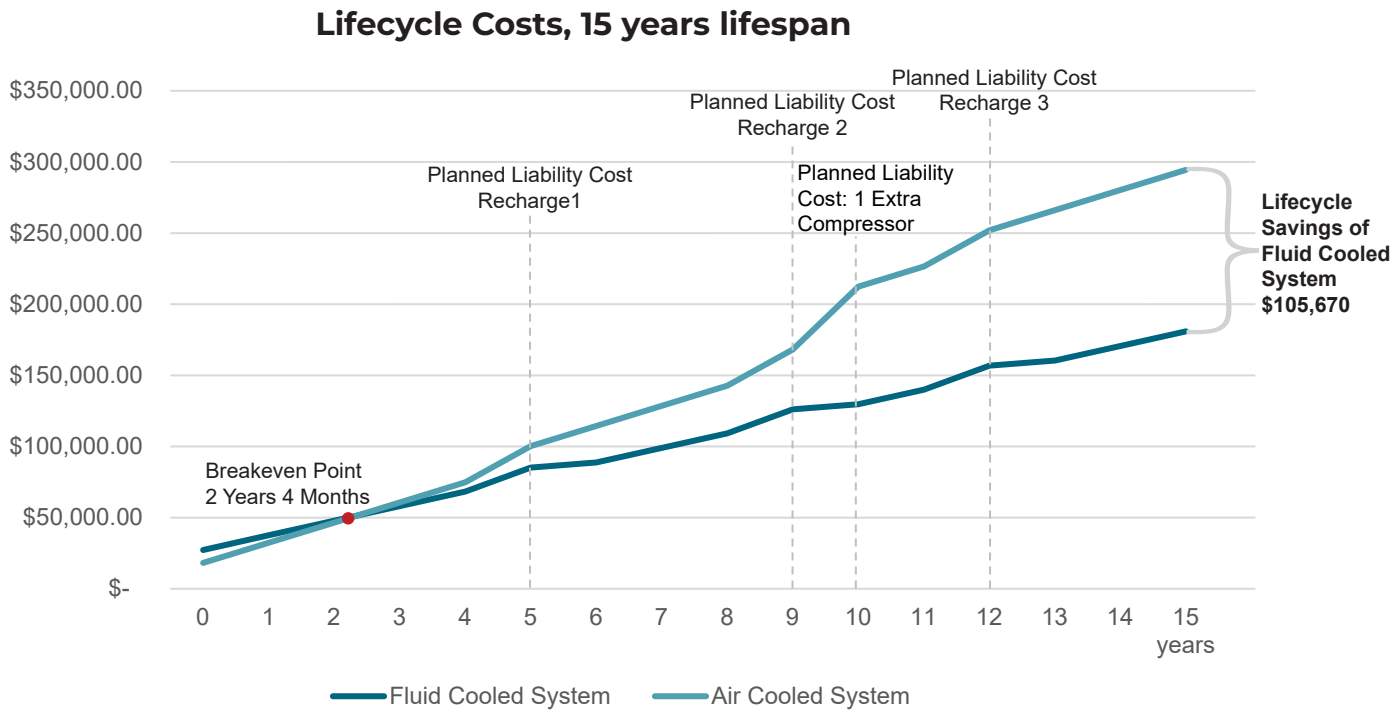
IV- First Cost and Total Cost of Ownership

Analysis done with a **40-ton indoor unit** with remote heat rejection

Payback Period: **2 Years and 4 Months**

Assumed fluid cooler premium to the Owner: **$26,000**





$50/lb R454B	Fluid-Cooled unit	Split DX – Air-Cooled	Split DX Air-Cooled Premium
Unit/Field Charge	100 Gallons Pre-mix Glycol ($7.50/gallon) = $750 No refrigerant field charge = $0	R454B Refrigerant ($50/lb) 452 lbs unit charge 300 lbs field charge = $15,000	$14,250
Piping Installation (100' Line)	200' PVC (2 Pipe) @ $2.50/ft = $500	400' Copper (4 Pipe) @ $8.00/ft = $3,200	$2,700
Total Split DX Air-Cooled Premium	-	-	$16,950
Real Premium of Fluid Cooler after Installation	-	-	$26,000 - $16,950 = $9,050

$50/lb R454B	Fluid-Cooled unit	Split DX – Air-Cooled	Split DX Air-Cooled Operating Premium
Annual Leakage over 15 years– Refill due to leaks	2% Leakage Rate x 88lb Unit Charge x $50/lb R454B = $88/year $88 x 15 years= $1,320 over 15 years	6% Leakage Rate x 452lbs Unit Charge x $50/lb R454B = $1,356 $1,356 x 15 years = $20,340	$19,020 over 15 years Annual: $1,268
Operating cost savings from 20% improvement [3]	32KW x 4000 hours x $0.10 kW X 80% = $10,240 per year. Over 15 years this is $153,600	32KW x 4000 hours x $0.10 per kWh X 100% = $12,800 per year Over 15 years this is $192,000	$38,400 over 15 years Annual: $2,560
Planned Liability Cost: Refrigerant Recharge of a single circuit 3 times in unit lifetime due to circuit leakages	Single Circuit 44lbs x $50/lb R454B = $2,200 $2,200 x 3 = $6600	Single Circuit 226lbs x $50/lb R454B = $11,300 $11,300 x 3 = $33,900	$27,300
Planned Liability Cost: 1 Extra Compressor Replacement [6]	$0	$30,000	$30,000

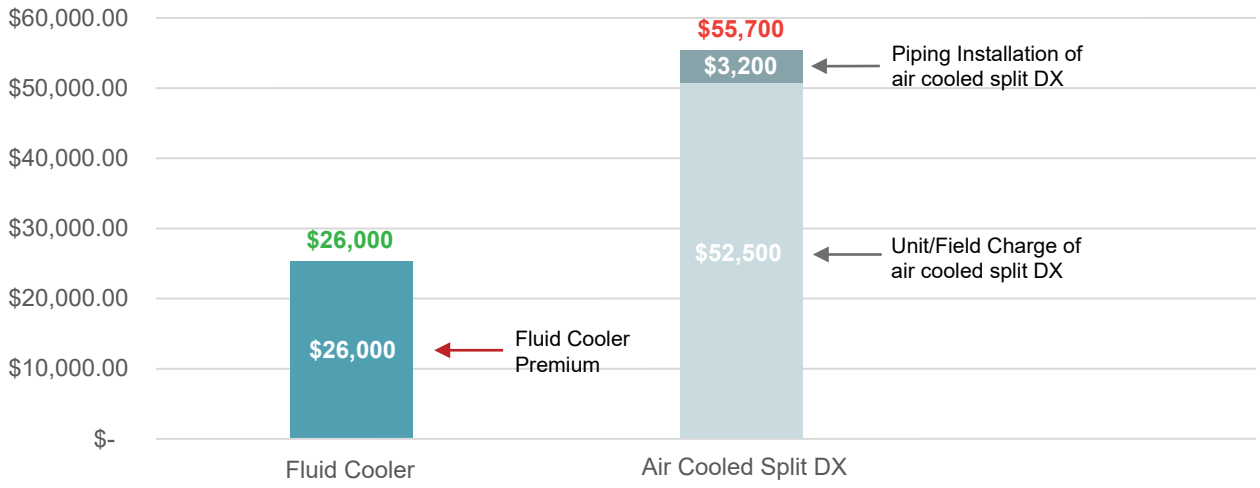
V- First Cost and Total Cost of Ownership

Volatile Refrigerant Market Conditions

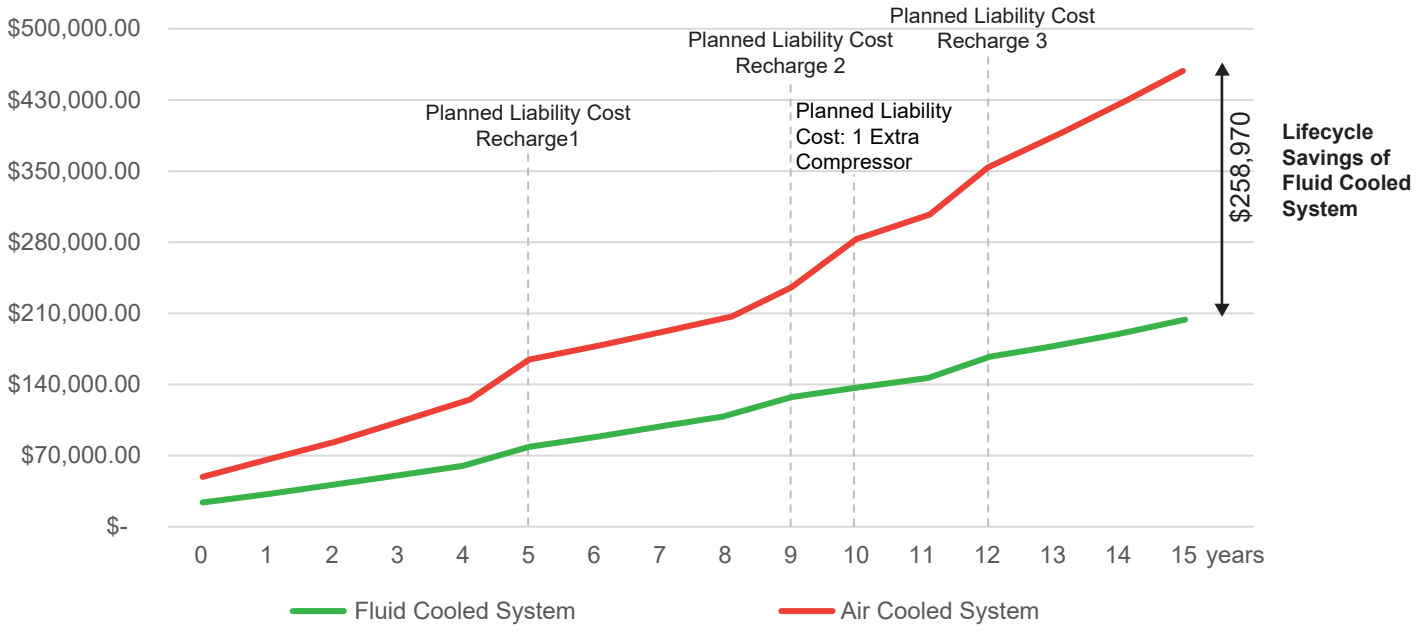
53% Lower Upfront Cost
Lower net installed costs with Fluid-Cooled Systems

145% Increased Lifecycle Savings
in Fluid-Cooled Systems

Net Installed Costs: R454B Pricing at $175/lb



Lifecycle Costs in Volatile Refrigerant Market Conditions



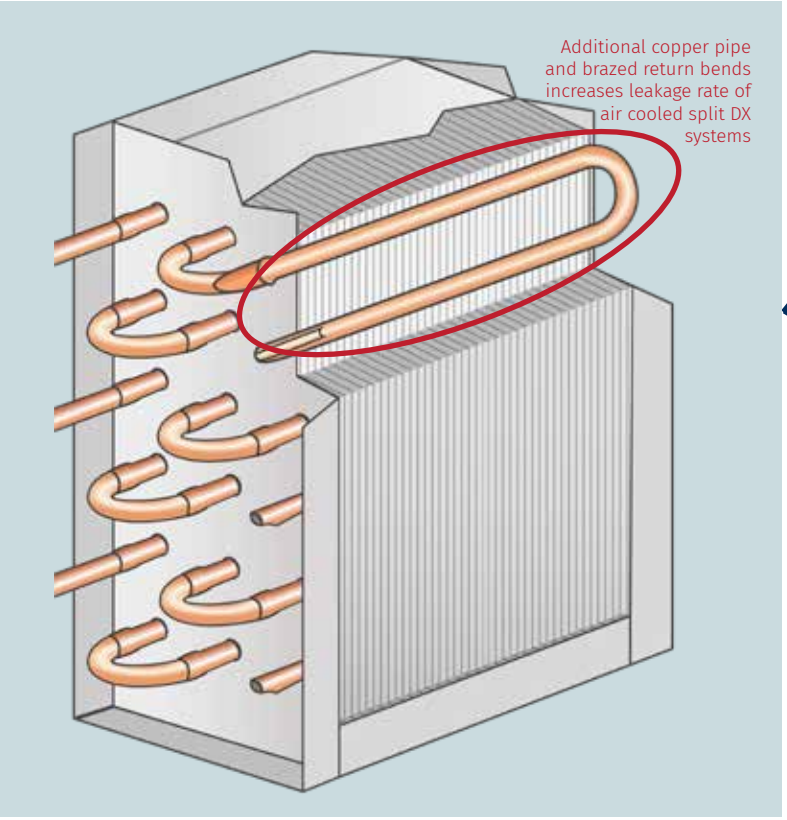
VI- The Hidden Costs of Air-Cooled Air Split DX Systems

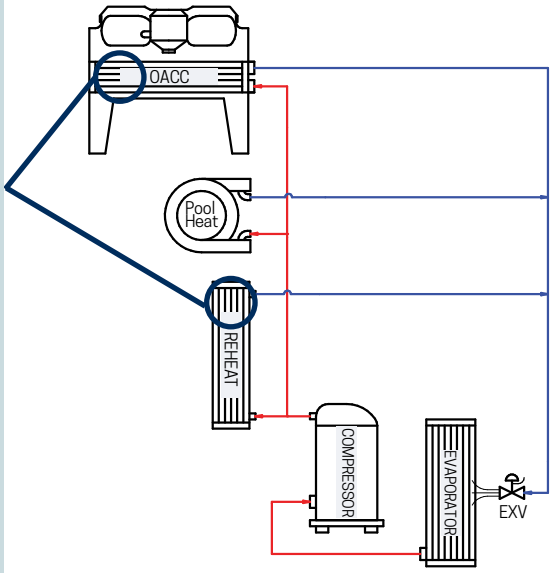
a- Net Installed Costs

- It is a commonly shared myth that first cost on a refrigerant-based system is much lower than that of a fluid-cooled system. When you factor in refrigerant and installation costs, net installed costs are actually very comparable between them.
- Extra in-field refrigerant charge
- Copper pipe installed by a certified installer versus PVC pipe
    - 2 or 3 compressor systems requires 2 or 3 pipe sets runs. Fluid-cooled units use a single PVC pipe to the dry cooler.
- Refrigerant specialties needed to protect the compressor (not included in calculation, but would increase the net installed cost of air-cooled split DX systems even further)

b- Annual Leakage

- A 40 ton fluid-cooled system has 88 lbs (2 x 44) compared to a split with condenser of 452 Lbs (2 x 226). That is a whopping 364 lbs more refrigerant.
- The annual leakage rate of a system with long piping runs is 6% compared to fluid-cooled systems at 2%[1] a 300% higher leakage rate for split DX systems compared to fluid-cooled systems![2]
- This is explained by the fact that adding the reheat coil and outdoor condenser coil adds 4000 linear feet of thin copper pipe (for maximum heat transfer) and 100s of brazed return bends (refer to the diagram below).





c- Operating Costs

- **Despite another common myth suggesting fluid-cooled systems using dry coolers are less efficient, systems with the same condensing pressures have the same performance.** If System A has the same condensing pressures as a dry cooler fluid cooled unit, the operation is identical besides the pump energy. In the case of a dehumidifier system manufactured by PoolPak, the pump energy is a 1% penalty on design days. If designing based on 1% weather data, the evaluation is based on less than 4 days a year, while the majority of the year, being off peak, would have better performance.
- **According to the Cooling Technology Institute, well-designed fluid cooled systems can have an annualized operating cost decrease of up to 37% due to improved compressor operation[3].**
    - A systems realizing just 20% better performance will save operating costs
    - If you have 40 ton compressors drawing 32 kW, you would see:
    - 32KW x 4000 hours x $0.10 per kWh X 20% = $2,560. Over 15 years this is $38,400 in energy savings.

d- Maintenance and Repair Costs

It is widely accepted that fluid-cooled compressors last longer than air-cooled compressors, with data sources showing consistently around 30% longer longevity for fluid-cooled compressors[4][5][6][7]. As a result, it is fair and conservative to say that in the 15-year lifespan of a dehumidifier, the air-cooled solution would require 1 additional compressor change as compared to the fluid-cooled equivalent. A compressor for a 40-ton unit will easily cost upwards of $30,000.
Throughout the 15-year unit lifespan, refrigerant circuits will likely be recharged 3 times due to circuit leakages. The enormous refrigerant charge required by outdoor air condensers directly translates into higher maintenance costs through refrigerant cost – over $34,000 in incremental cost over its lifespan!

e- Refrigerant Price and Supply Volatility

Price and availability of refrigerant can be highly volatile depending on market conditions. The original lifecycle analysis assumed a refrigerant price of $50/lb. However, as of May 2025, prices have surged as high as $4,000 per 20 lb cylinder (equivalent to $200/lb). For this updated analysis, we've used $3,500 per 20 lb ($175/lb) which is the most commonly observed market rate. This increase significantly impacts the economics of air-cooled systems, which require large refrigerant volumes and are more vulnerable to leakage and supply shortages.

With current pricing, the projected 15-year cost differential between air-cooled and fluid-cooled systems could increase from $105,670 to more than $258,970, making fluid-cooling not only a performance advantage but also a risk mitigation strategy in unpredictable markets.

Beyond price increases, the lack of consistent refrigerant availability has become a serious operational risk. In critical applications, such shortages could lead to system downtime or delay the startup. By contrast, fluid-cooled systems like PoolPak's PPK series come factory-charged, ensuring peace of mind despite ongoing refrigerant supply challenges.

VII- Compliance

- UL 60335-2089 only supports certification of systems up to 166 lb/circuit. There are significant restrictions on systems with over 166 lb per circuit, and special equipment certifications would be required, which could cost between $5,000 to $30,000 depending on the type required.

  to identify leaks and repair the appliance.
  - Owners/operators must maintain hard or electronic copies of:
    - Records documenting the full charge of appliances.
    - Records, such as invoices, showing when service or maintenance is performed, when refrigerant is added to an appliance (or removed, in the case of disposal), when a leak inspection is performed, and when a verification test is conducted.

VIII- Location Limitations

Maximum lines sets of 50' are generally recommended for outdoor condensers. Anything more are generally considered too long for outdoor condensers because the refrigerant charges get very large and refrigeration specialties are required to protect the compressor from oil and refrigerant migration. Neither an owner nor a service technician want to deal with this additional complexity over the life of the system.

If installing a condenser below the unit, the condenser must be oversized for extra subcooling. Subcooling the liquid is needed to overcome the pressure losses pushing the liquid column back up to the unit. This results in a larger footprint, and higher upfront and operational costs than the application requires.

IX- Reliability and Serviceability

Fluid cooled units are simple and easier to service and maintain than air-cooled equivalents. A fluid-cooled system has a compact factory-packaged refrigeration circuit that could not be simpler for indoor pool dehumidifiers: evaporator and condenser along with a pool water heater.

In the case of a dehumidifier manufactured by PoolPak, the system also has multiple small refrigerant circuits in a compact and easy to follow manner. Except for the evaporator coil, everything is in the service vestibule. Any AC service technician would be comfortable and well-versed with this refrigeration set up.

In contrast, A split DX has refrigeration components and piping in the mechanical room and outdoors. Systems with remote condenser: Evaporator, reheat coil, pool water heater, AC condenser, oversized receiver, oil separator, suction accumulator, all spread out over 100s and 1000s of feet of copper refrigerant lines. This makes it difficult to diagnose and track issues and their root cause(s). Only highly specialized refrigeration technicians are qualified to service and maintain these systems, and "highly specialized" is a synonym for "expensive"!

Depending on the geography, various local codes and regulations could apply, including having a full-time certified refrigeration technician on staff for units with high refrigerant charge[8]. DAS units operate at lower operating temperatures and as a result the glycol is stable and generally is not necessary to replace over the life of the unit. Testing should occur annually.

X- Comparison Summary

Component	PoolPak's Fluid-Cooled System	Air-Cooled Split DX System
Evaporator	Refrigerant	Refrigerant
Fluid cooled Heat exchanger	Refrigerant	N/A
Pool water heater	Refrigerant	Refrigerant
Reheat coil	Fluid Fully modulating (0-100%)	Refrigerant (On/off)
Extra Copper piping	None – uses ultracompact fluid-cooled plate condenser	Adds 4000 linear feet of thin walled copper pipe in reheat and outdoor condenser coils
Outdoor AC heat exchanger	Fluid cooler Fully modulating (0-100%)	Refrigerant condenser (on/off)
Location limitation	No limitations to dry cooler	50' max line length recommended to outdoor condenser
Refrigeration specialties required to protect the compressor	No	Yes: oil separator, oversized receiver, suction accumulator on each circuit.
Seasonal Refrigerant migration outdoors	No	Yes
Critical refrigerant charge	No	Yes
All refrigeration components inside the dehumidifier	Yes	No
Special operating sequence to return oil and refrigerant back to the unit	No	Yes
Complex External piping	No: simple PVC	Yes; Refrigerant piping with oil traps at each riser for oil management

Did you know?

PoolPak provides pre-engineered fluid-cooled solutions. All that would be needed in the field is PVC piping and a glycol/water fill. Pumps, expansion tanks, fill valves and any other specialties are factory provided to make the installation of these systems absolutely simple.

XI- References

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