

Retrofit Roofs Offer Design, Environmental, and Financial Benefits in New and Existing Construction

The purpose of this white paper is to introduce the various applications for retrofitting roofs with metal systems. It covers the applications, the benefits, technical aspects and opportunities for the use of metal roof systems in the retrofit process in new and existing construction.

In this paper, retrofit refers to a complete, fully engineered metal system designed for installation over existing flat or sloped roofs made of various types of material. For architects retrofit presents an opportunity to expand business, particularly with reroof, where architects have previously not been involved.

For building owners retrofitting provides a number of benefits:

- Improved appearance for existing buildings
- Ease of installation in new construction
- Reduced environmental impact
- Improved energy efficiency

Existing Building Solutions

For a little over 25-years, retrofit has been a quick, cost effective solution for problematic roof geometry, maintenance issues and outdated appearance. In more recent years, thermal efficiency and energy savings are the hallmarks of a retrofit roof application.

As building owners become more involved in energy and environmental issues they are finding greater benefits from retrofitting roofs with metal. In addition to being aesthetically pleasing, metal is a sustainable material that is made from recycled materials and is fully recyclable. Metal also has reflective and emissive benefits, so it reduces heat gain and the building's carbon footprint. It may also add points in seeking certification under the USGBC's LEED building guideline program. Installing a retrofit system typically does not require removal of the existing roof or wall material so it also reduces landfill waste.

By solving roofing problems, a retrofit system helps reduce roof maintenance and offers a long service life. The key to this is the use of metal roofing. It has a service life of nearly double its closest competitive roofing system, which currently is modified bitumen or built-up roofing (BUR), according to a market survey of building owners conducted by Ducker Worldwide, Troy, MI. The study showed the life of a Galvalume® metal roof at 41.6 years; BUR at 23 years; and modified at 23 years. Statistics from the same study put maintenance costs of metal roofing at 10 cents (USD) per square foot per year, compared to BUR and modified both at 17 cents.

Roofing Applications

The most common retrofit applications are metal over existing flat roofs and metal over existing sloped roofs. Both of these improve a building's appearance and reduce maintenance, but each can offer solutions to different problems.

All retrofit systems are fully engineered. From the design phase through completion of installation several steps must be taken to ensure the integrity of the system and the project.

Key steps that need to be considered in the design phase include:

- Inspect the existing roof thoroughly;
- Analyze the roof structure to ensure it can hold the added weight of 2 to 5 pounds per square foot, depending on the gauge of the new metal roof and the required support framing system to meet building codes;
- Determine the engineering needed on support framing and anchorage systems;
- Specify temporary waterproofing at anchors into existing structure;
- Evaluate other opportunities to improve efficiency such as a more balanced ventilation system, more insulation to meet new energy code requirements, and renewable energy systems.

These steps are essential. In particular, the ability of the existing building to accept the new retrofit system must be analyzed by an independent engineer. This will determine the proper construction of the system and that it meets all life-safety standards.

It also is imperative that the new retrofit system be properly anchored to the existing roof's structural system. Improper attachment can result in the new roof system being torn from the building in severe wind uplift. It has been documented in wind uplift tests that proper attachment is the main factor in system integrity.

Existing Flat or Nearly Flat Roof Solutions

The two common types of retrofit installations on existing structures are low slope and steep slope roofs. During installation of either of these types of retrofit systems the building interior is not exposed to outside elements or contamination from construction.

Low slope installations are usually utilitarian and economically driven. A variety of framing methods can be used to turn a flat roof into a new roof sloped with a pitch from $\frac{1}{4}$ to a maximum of 2:12. Typically a low slope application does not add curb appeal but is designed to improve discharge of rainwater.

Retrofit systems can solve other problems that may result from existing roof geometry such as poor drainage, snow drifting, or the addition of a new building adjacent to the existing structure.

Steep slope installations have a slope greater than 2:12. They are more architecturally driven and turn a flat or minimal sloped roof into a design element. Environmental features can also be incorporated in steep slope installations, such as snow retention, cool roof coatings, and renewable energy systems.



Typical low-slope application over nearly flat roof



Reverse slope application to discharge rainwater from neighboring property

When steep sloped metal roofs are installed over conventional membrane, tear-off of the existing roof is normally not required and removal of existing roof insulation may not be necessary unless required by local codes.

The International Building Code (IBC-2006) requires some existing membrane materials to be removed, but it allows an exception for reroofing buildings that have existing metal roofs. A metal roof does not have to be removed.

In all cases a properly designed retrofit system improves thermal resistance and offers a balanced ventilation system. If needed, additional insulation can be installed during the retrofit process.

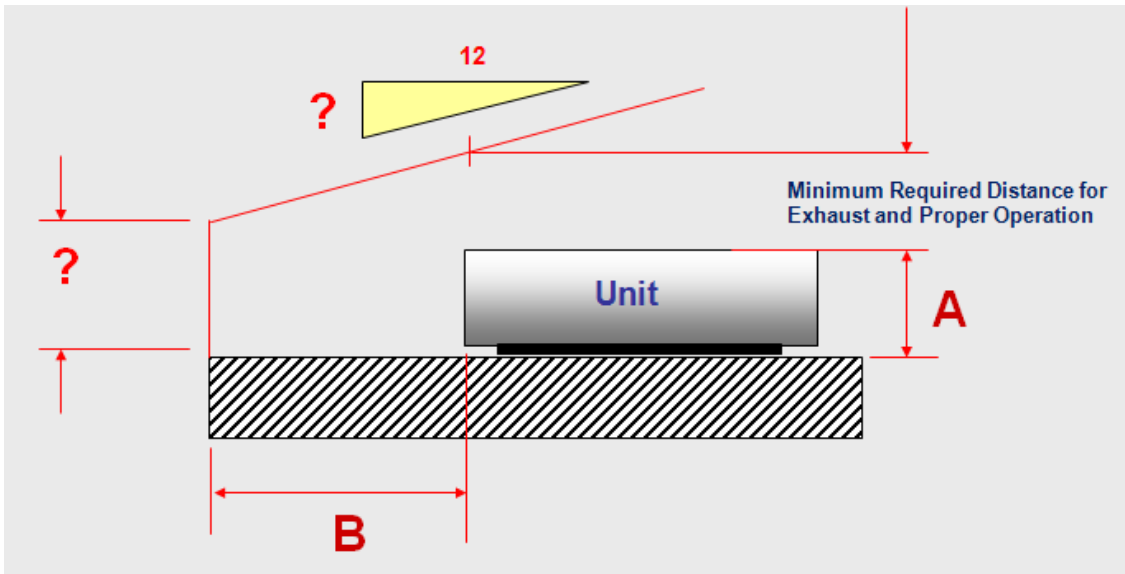
In new construction, retrofit framing can be used as a cost effective alternative to other light-gauge or structural framing methods. Framing for this type of retrofit system is essentially fabricated in the field and erected directly onto a concrete deck.

Rooftop Equipment

A key consideration in designing a retrofit system for flat roofs is location of the rooftop equipment. Typically this involves air handling and non-air handling equipment for heating and air conditioning systems, as well as skylights, sanitary vents, exhaust fans, and fresh air intakes. How this equipment fits into the retrofit is up to the designer, but the location of existing equipment usually dictates what can be done.

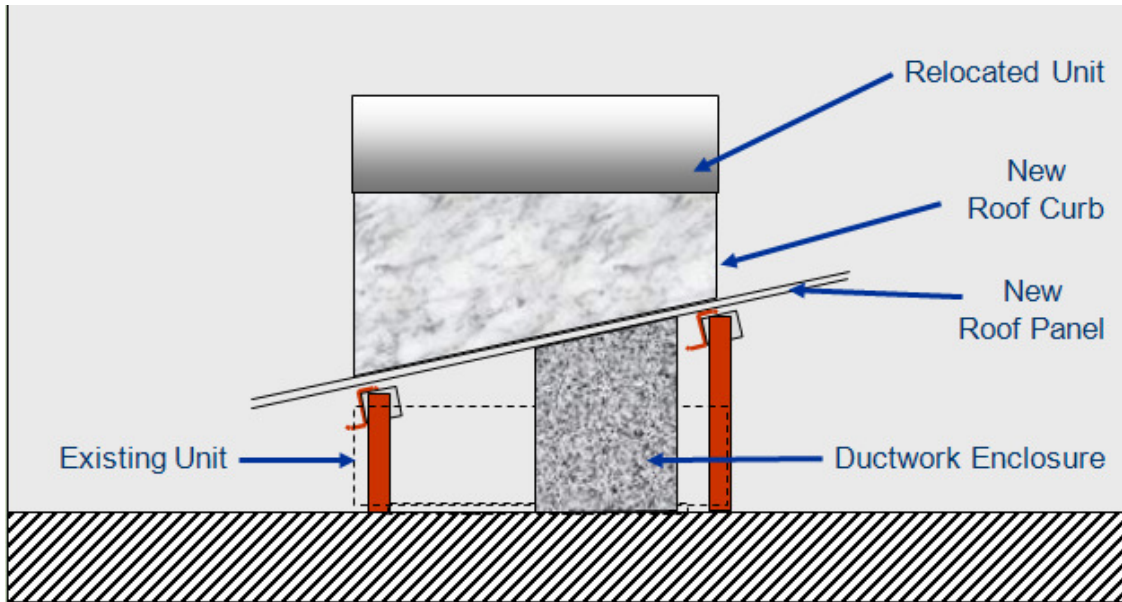
The first option may be to roof over the existing equipment. This will be determined by first evaluating all aspects, including required exhaust needs.

Another option is to relocate the air-handling units above the new roof plane. If this is the desired application, a structural support system must be engineered to accommodate the weight of the existing equipment. In addition, new air handling ductwork will have to be installed from the relocated unit to the existing roof penetration. It is recommended to only use curbs approved by the new roof manufacturer.



Roof over HVAC Equipment - the location of the existing equipment may dictate what can be done.

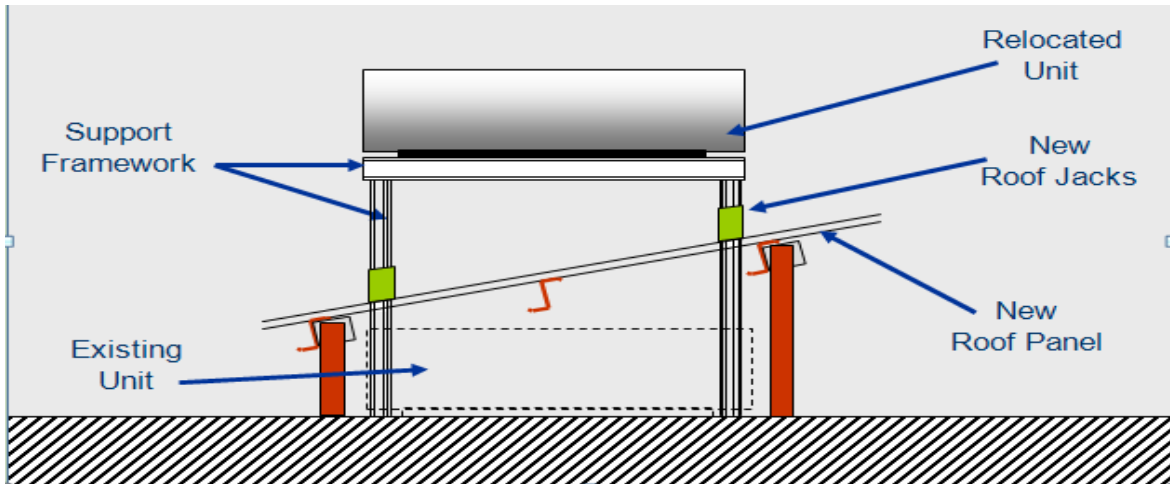
A third option is to relocate all the larger equipment to a common area in a mechanical well. In this case the overall design must accommodate the well in the roof geometry and new ductwork will need to be routed to existing roof penetrations.



Air-handler raised to new roof

Non-air handling equipment can be relocated to a platform above the new roof.

Electrical and plumbing equipment, exhaust fans and fresh air intakes can also be extended through the new roof, with a curb for the fans and air intakes. The design should also include access for maintenance and potential replacement of these items.



Non Air-handling Equipment Raised to Platform

Existing Sloped Roof Solutions

Designing retrofit systems for sloped roofs requires attention to many of the same details in the design stage as for flat roofs. These include analyzing the existing roof support system and using the opportunity to improve ventilation systems and insulation levels, and potentially adding renewable energy systems to the design.

In sloped roofs it also is important to determine the necessary wind uplift performance so that the system meets applicable building code requirements. Both metal and conventional sloped roofs can be retrofit with metal roof systems.

Existing metal roofs are either ribbed panels or standing-seam panels. In a metal-over-metal situation, new sub-framing is installed over existing purlins and joists. Some systems are also notched to nest with the existing metal roof profile, which will also strengthen the roof's corner and edge wind zone areas and allow for an upgrade to currently adopted building code wind speeds.

Conventional roofs are typically one of four types: composition shingles, built-up (BUR), single-ply, or modified-bitumen. When a metal roof is retrofit over conventional roofing materials, a new support framing system is anchored to the existing structure. This new framing system must be engineered to maintain the structural integrity of the existing roof's support framing, where the newly imposed loads are properly distributed. It is important to note that flat roofs are generally designed to uniformly distribute loads, where a retrofit framing system will impose a series of concentrated loads into the existing roof

framing. Because of this, a structural engineer should conduct a design analysis to confirm the existing roof will not be overloaded

Energy Efficiency

The retrofit process offers some excellent ways to improve a building's energy efficiency and help reduce its carbon footprint. By adding a few low cost elements to the retrofit system the designer can help the building owner realize significant savings.

These elements can include extra insulation for improved thermal resistance, installation of a radiant barrier and the creation of more ventilating space. Another consideration in designing the retrofit system is to use solar technologies to add thermal heat-recovery or power systems.

Older flat and sloped roofs typically are not energy efficient because of poor insulating qualities. On average, they have thermal resistance (R) values between R-6 and R-10, which is inadequate thermal protection and far below most local building energy codes. Today, most building codes have minimum R values based on ASHRAE 90.1 and the Federal Model Energy Code. For example, in Climate Zone 3, ASHRAE 90.1-2007 recommends R-19 for roofs on metal buildings, R-20 for roofs on buildings with insulation entirely above the deck, and R-38 for roofs on buildings with attics.. Adding insulation in a retrofit application can improve the building's thermal efficiency and may also represent a tax benefit to the building owner.

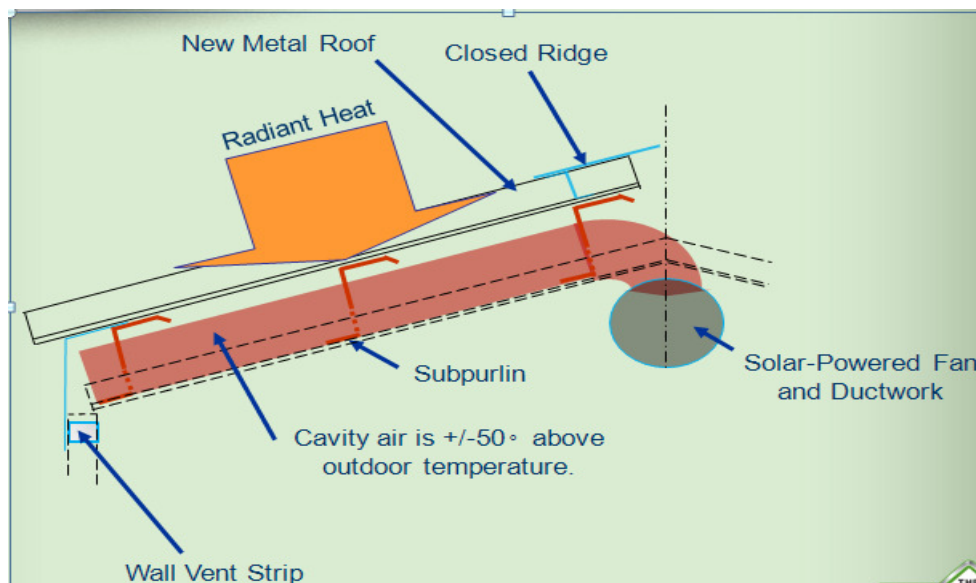
Whether a retrofit is over existing flat or sloped roofs, a properly designed and balance ventilation system must be included in the assembly. Doing so eliminates any potential condensation issues and allows the building to meet airflow rates required by code.

Clearly a major energy benefit in a retrofit system is the increased natural ventilation, especially in steep-slope metal-over-metal applications, provided by convection that is inherent in a retrofit application. This is referred to as above sheathing ventilation (ASV).

In a direct-to-deck set up, heat is conducted through the roof. With the ASV provided by a retrofit system, heat is dissipated through the ridge vent in hot weather and the air space acts as an insulating layer in cold weather to reduce heat loss. Research conducted by Oak Ridge National Laboratory (ORNL), Oak Ridge, TN has confirmed that ASV provides up to a 30 percent reduction in heat gain through the roof and that this can be increased to 45 percent when a "cool" surface, such as the cool coatings offered on metal roof systems, is used. The building owner may also be eligible for Federal tax benefits through the use of ASV.

Another way to increase energy savings is to include solar systems in the retrofit design, which may also qualify the building owner for Federal solar-energy tax credits. Rooftop solar systems capture the hot air between the old and new roofs that can be used to heat or provide energy for the building. Solar systems can be focused on heat recovery, water heating or power production. Feasibility for use on any building is subject to solar insolation values, which need to be determined in the design stage.

A solar heat recovery system collects radiant-heated air and redistributes it to the building's existing HVAC system. Solar water heating uses a looped tubing system that carries water glycol fluid heated by the sun's radiant heat. The glycol prevents the water from freezing in cold weather. This technology can be used to heat the building or to provide hot water for processes. The tubing is installed between the existing and new roofs and can be routed to the building walls and/or floors to bring radiant heat into the building. To heat water, swimming pools and/or process equipment, the tubing can be routed to heat exchangers located in tanks or other types of vessels.



Solar Heat Recovery

Photovoltaic (PV) technology creates a roof top platform to use the sun's heat for solar electricity systems. Current PV system types include: thin film; amorphous silicon (a-Si); and polycrystalline silicon. Newer PV materials are being developed which include cadmium telluride (CdTe); copper indium selenide (CIS); copper indium/gallium diselenide (CIGS); light-absorbing dyes; and dye-sensitized solar cells [DSSC].

Several important factors come into play when installing PV systems on metal roofs and on conventional roofing systems. A metal roof accommodates necessary PV attachment

hardware without roof penetration. Any rack-mounted PV system attached to a conventional roof requires penetration of the roof surface and subsequent waterproofing at the solar array attachments points. Because the service life of a conventional roof membrane is less than that of a PV system, the PV system will need to be dismantled and reinstalled when the old roof needs to be replaced. So any cost calculation for installing a PV system over a conventional roof must include long-term roof-replacement costs.

Since the service life of a metal roof is longer than that of the PV system, mounting a solar system on a sloped metal roof provides savings of 24 percent to 43 percent compared to a conventional roof system.

Using a standing seam metal roof with a PV system also offers Federal solar-energy tax credits, which have been extended through December 31, 2016. These include a rebate of 30 percent of the entire system cost; accelerated depreciation schedule (IRS sec 179b); and a 50 percent, first-year bonus depreciation with the balance depreciated over the following 5 years. Additional state and local tax and utility incentives for solar systems and metal roofing can be determined by visiting www.dsireusa.org.

In addition to the immediate Federal or state rebates and incentives, the building owner will realize savings from reduced energy use throughout the life of the PV system.