LANDMARK RESURRECTION

BY ROGER CHANG, P.E., ASSOC. AIA

Transforming a treasured historic landmark into an energy-efficient building is a challenging goal requiring a delicate balancing act. The renovation of the Wayne N. Aspinall Federal Building and U.S. Courthouse in Grand Junction, Colo., exemplifies the balance of preservation and sustainability.

The project preserves an anchor in the community and the building’s historic character, and converts the 1918 landmark into one of the most energy-efficient, sustainable historic buildings in the country. The design has received LEED Platinum certification and aims to be the U.S. General Services Administration’s first site net zero energy facility on the National Register of Historic Places. The net energy use intensity (after on-site solar) for the first year after renovation was 10.39 kBtu/ft² yr. Originally designed under U.S. Treasury Department supervising architect James Wethorne, the building was first constructed as a U.S. Post Office and Courthouse in 1918. In 1938, a substantial addition was added during the recent modernization was completed not to be visible from the principal south elevation. A new entrance ramp is provided for improved accessibility.

Exterior upgrades and roof replacement featuring ENERGY STAR membrane and photovoltaic arrays are sensitively designed to be compatible with historic assets. This project creates awareness of measures that can reduce energy use in a historic structure without a material impact on the historic fabric, and demonstrates the use of alternative energy that can supplement traditional conservative methods, allowing historic buildings to achieve minimal to zero net energy use and energy independence.

Design Approach

The design-build procurement approach was used to provide a high-performance project within budget and with an aggressive schedule. The approach acknowledged the federal government’s goal to be carbon neutral by 2030, and creates a “green proving ground,” demonstrating how to potentially make an existing historic building perform at net zero energy.

To meet energy independence and energy-efficiency goals (50% more efficient than ASHRAE Standard 90.1-2007), the sustainable design includes: a rooftop 123 kW photovoltaic array, addition of spray foam and rigid insulation to the building shell; storm windows with solar control film to reduce demand on HVAC; variable refrigerant flow and cooling systems tied to a 32-well geothermal loop; a dedicated outdoor air system (DOAS) with evaporative cooling and heat recovery; wireless lighting controls and state-of-the-art fluorescent and LED lighting upgrades; and post-occupancy monitoring capability.

New mechanical, electrical and life safety systems were sensitively designed not to disturb the building’s historic fabric. Due to the highly restricted site and historic character, and converts the 1918 landmark into one of the most energy-efficient, sustainable historic buildings in the country. The design has received LEED Platinum certification and aims to be the U.S. General Services Administration’s first site net zero energy facility on the National Register of Historic Places. The net energy use intensity (after on-site solar) for the first year after renovation was 10.39 kBtu/ft² yr. Originally designed under U.S. Treasury Department supervising architect James Wethorne, the building was first constructed as a U.S. Post Office and Courthouse in 1918. In 1938, a substantial addition extended the building to the east.

The three-story multiuse building now houses the U.S. District Courts and various federal agencies. Funded by the American Recovery and Reinvestment Act, the 2013 $15 million modernization restores historic volumes and finishes, while providing complementary, contemporary design. Innovative building systems, such as wireless lighting, allow prominent spaces to be preserved and showcased, while drastically reducing energy consumption.

When not including the cost of the PV system, the renovation cost was comparable to market rate costs for new construction.
**ENERGY AT A GLANCE**

- **Annual Energy Use Intensity (EUI) (Site)**: 10.4 kBtu/ft²
- **Renewable Energy (Produced and Consumed On-Site)**: 10.8 kBtu/ft²
- **Annual Source Energy**: 34.7 kBtu/ft²
- **Annual Energy Cost Index (ECI)**: $0.53/ft²
- **Annual Net Energy Use Intensity**: 21.2 kBtu/ft²
- **Annual Load Factor**: 68.7%
- **Annual Energy Use Intensity (EUI) (Site)**: 34.7 kBtu/ft²
- **Annual Energy Use Intensity (Site)**: 21.2 kBtu/ft²
- **Annual Net Energy Use Intensity**: 2e/ft²
- **Annual Energy Cost Index (ECI)**: $0.53/ft²
- **Annual Source Energy**: 34.7 kBtu/ft²
- **Annual Net Energy Use Intensity**: 21.2 kBtu/ft²
- **Annual Load Factor**: 68.7%
- **Annual Energy Use Intensity (Site)**: 34.7 kBtu/ft²

**Savings vs. Standard 90.1-2007**

- **WATER AT A GLANCE**
  - **Annual Water Use**: 174,877 gallons
  - **includes impact of evaporative fluid cooler**

**EASE AT A GLANCE**

- **Actual Gross**
  - **Predicted**

**LIGHTING**

Light-colored parking lot paving reduces urban heat island impacts. The use of low-emitting and fuel-efficient vehicles is encouraged with two dedicated parking spaces. The overall landscape approach is low impact, with preservation of existing trees on the site, supplemented with limited use of grass to create a welcoming environment.

**CLIMATIC DESIGN**

Grand Junction,Colo., is located in ASHRAE Climate Zone 3B, which experiences a wide range of dry-bulb temperatures with low overall relative humidity and less than 10 in. of rain per year. Solar availability for renewable energy generation is high.

The existing building consists of a high thermal mass construction, which was augmented with interior insulation systems to retain the benefits of thermal capacitance to increase the thermal stability of the internal environment. This design allows HVAC systems to react more quickly during morning warm-up and cool-down. The design team maintained the historic appearance of existing fenestration systems while reducing solar gain and thermal conductance, using new internal storm windows with high-performance spectrally selective film.

**IMPROVING FUNCTIONALITY, RESTORING HISTORY**


Prior to the modernization, several tenants had workers split across multiple floors and spaces. The building also had a limited entrance lobby, which was significantly improved for better wayfinding and to provide gathering areas for larger functions. During the 1970s, acoustic tile ceilings were incorporated throughout the building, reducing natural daylighting potential and floor-to-floor heights. The modernization restored ceilings to their original heights and repaired decorative plaster detailing.

The existing building consists of a high thermal mass construction, which was augmented with interior insulation systems to retain the benefits of thermal capacitance to increase the thermal stability of the internal environment. This design allows HVAC systems to react more quickly during morning warm-up and cool-down. The design team maintained the historic appearance of existing fenestration systems while reducing solar gain and thermal conductance, using new internal storm windows with high-performance spectrally selective film.

**SITE**

The project preserves the historic significance of Grand Junction’s crown jewel, while modernizing the landmark. Located in the central business district of a community that serves as a regional anchor, the project demonstrates reinvestment and partnership with a community to reinforce urban fabric and livability, including access to the city’s adjacent alleys to install 12 of the geoechange wells.

Reinvesting in this optimal urban site allows for easy access to many of Grand Junction’s downtown amenities and public transportation. Enhanced pedestrian access includes new accessible (Architectural Barriers Act Accessibility Standard-compliant) entrance ramps.

Above North elevation. The photovoltaic array is finished with a white reflective material, to support daylighting within the original light well. Below left Restored visitor reception area. The use of translucent partitions allows greater daylight penetration to the IRS service center. Below right Restored visitor reception area.

The courtroom was restored with updated finishes and new LED lighting systems, and dedicated fan coil units with direct ventilation air supply.

Light-colored parking lot paving reduces urban heat island impacts. The use of low-emitting and fuel-efficient vehicles is encouraged with two dedicated parking spaces. The overall landscape approach is low impact, with preservation of existing trees on the site, supplemented with limited use of grass to create a welcoming environment.

**CLIMATIC DESIGN**

Grand Junction, Col., is located in ASHRAE Climate Zone 3B, which experiences a wide range of dry-bulb temperatures with low overall relative humidity and less than 10 in. of rain per year. Solar availability for renewable energy generation is high.

The existing building consists of a high thermal mass construction, which was augmented with interior insulation systems to retain the benefits of thermal capacitance to increase the thermal stability of the internal environment. This design allows HVAC systems to react more quickly during morning warm-up and cool-down. The design team maintained the historic appearance of existing fenestration systems while reducing solar gain and thermal conductance, using new internal storm windows with high-performance spectrally selective film.

**IMPROVING FUNCTIONALITY, RESTORING HISTORY**


Prior to the modernization, several tenants had workers split across multiple floors and spaces. The building also had a limited entrance lobby, which was significantly improved for better wayfinding and to provide gathering areas for larger functions. During the 1970s, acoustic tile ceilings were incorporated throughout the building, reducing natural daylighting potential and floor-to-floor heights. The modernization restored ceilings to their original heights and repaired decorative plaster detailing.

The existing building consists of a high thermal mass construction, which was augmented with interior insulation systems to retain the benefits of thermal capacitance to increase the thermal stability of the internal environment. This design allows HVAC systems to react more quickly during morning warm-up and cool-down. The design team maintained the historic appearance of existing fenestration systems while reducing solar gain and thermal conductance, using new internal storm windows with high-performance spectrally selective film.

**SITE**

The project preserves the historic significance of Grand Junction’s crown jewel, while modernizing the landmark. Located in the central business district of a community that serves as a regional anchor, the project demonstrates reinvestment and partnership with a community to reinforce urban fabric and livability, including access to the city’s adjacent alleys to install 12 of the geoechange wells.

Reinvesting in this optimal urban site allows for easy access to many of Grand Junction’s downtown amenities and public transportation. Enhanced pedestrian access includes new accessible (Architectural Barriers Act Accessibility Standard-compliant) entrance ramps.

Above North elevation. The photovoltaic array is finished with a white reflective material, to support daylighting within the original light well. Below left Restored visitor reception area. The use of translucent partitions allows greater daylight penetration to the IRS service center. Below right Restored visitor reception area.

The courtroom was restored with updated finishes and new LED lighting systems, and dedicated fan coil units with direct ventilation air supply.
The installed lighting power density is 0.76 W/ft². Actual measured peak lighting power has been between 0.3 W/ft² and 0.4 W/ft².

**HVAC**

Natural ventilation was evaluated, but was determined to conflict with the need for increased building security, as well as regulation of HVAC systems. Building services are installed in soffit zones immediately outboard of double-loaded corridors to allow for higher daylighting potential and restoration of historic corridors to their original volume. The main heating and cooling plant consists of six twinned ground-source variable refrigerant flow (VRF) heat pump units (consisting of two modules sharing a common refrigerant connection), tied to a 32-well geothermal loop. The wells are 475 ft deep to maximize use of the site.

Due to a relatively high ground temperature of 62°F, an evaporative fluid cooler is available to allow energy balance of the loop. Variable frequency drives are used to vary geothermal loop flow rates in response to unit needs. The estimated block cooling load is 60 tons.

Daylight sensors automatically dim ambient lighting to achieve 30 footcandles. Roller shades are available to further control daylight and solar gain to match task needs.

A restored skylight was installed over the main tenant space on the first floor to allow deeper daylight penetration in the largest open office area in the building. On the second and third floor, perimeter ceiling zones are kept free of building services to allow maximum daylight penetration. A wireless lighting control system reduces wiring demands. Vacancy sensors are used throughout the building, with a 15 minute delay.

A healthy environment is promoted through the use of source control measures and roof-mounted dedicated ventilation system. The dedicated ventilation unit serves...
The intent is to share the wisdom learned from the project with the broader building community. An energy dashboard in the lobby provides a public display of the building’s performance.

The building was dedicated in February 2013. After the dedication, data from the building automation system started to be reviewed in detail and revealed higher than expected energy use due to unoccupied hours lighting, unoccupied hours plug load, and HVAC systems.

The team discovered that some lighting systems were not going into a nighttime mode (approximately 2 kW excess). The team also discovered that equipment in several tenant agencies was not shutting down at night (approximately 5 kW excess). And, several components of the HVAC systems were not running optimally: condenser water pumps were running in constant rather than variable mode, thermostat settings were not optimized by season and heating plant staging was not tuned by season (approximately 10 kW excess). Note that only 1 kW of extra demand equates to 8,760 kWh, or 5% of the building’s total energy budget.

PV output has also been less than expected, due to soiling, which required hand cleaning. This soiling is exacerbated by Grand Junction’s arid climate. A recent single-event snowfall in December 2013 also impacted PV output.

Through July 2013, the team made controls adjustments, which helped reduce nighttime demand significantly. Between August 2013 and present, additional minor adjustments have been made. In 2014, tenants were incentivized to further reduce their plug load energy use through a GSA pilot leaseback credit program in which tenants who hit predetermined plug load energy use targets receive a credit to their lease amount.

Based on data collected in 2013, the design energy model was recalibrated to reflect new nighttime plug load demand, to further assist with analysis of building system performance. In early 2014, the VRF system was rechecked by the manufacturer. It was determined that due to very low overall demand, the VRF system was cycling more than expected, resulting in low overall energy use, but higher than expected kW/ton energy use.

The current phase of measurement and verification will continue through October 2014. It is anticipated that future efforts will focus on further reducing tenant demand and making continuous control system adjustments to match use.

ENERGY PERFORMANCE

Shut-off variable air volume boxes located on each floor. A small water-to-water heat pump heating-only plant also is provided and serves the dedicated ventilation unit, first-floor perimeter heating and vestibule heaters.

Each tenant space includes carbon dioxide sensors to track air quality. Ventilation rates can exceed ASHRAE 62.1-2010 breathing zone rates by 30%.

ENERGY USE, COST COMPARISON

<table>
<thead>
<tr>
<th>Pre-Renovation FY 2008</th>
<th>Post-Renovation March 2013 to Feb. 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Renovation EUI 21.2 kBtu/ft² (gross)</td>
<td>Revised Gross Targeted EUI 20.24</td>
</tr>
<tr>
<td>Annual Energy Cost $32,936</td>
<td>Actual Gross EUI 21.39</td>
</tr>
<tr>
<td>Annual Energy Cost Index $0.79/ft²</td>
<td>Actual Net EUI 10.39</td>
</tr>
</tbody>
</table>

Note: Energy cost represents consumption and demand only. The building team is working with the utility to change the rate structure to one that is based on time of use and recognizes that the building has a PV rate copy rooms and custodial areas, particulates is achieved with separations, walls and ceilings). Materials and finishes have low-VOC content. Minimal exposure to chemicals and particulates is achieved with separate copy rooms and custodial areas, walk-off mats, and green housekeeping practices.

Passive Survivability. Daylighting in the most regularly occupied spaces allows continued use of office areas during a power outage. A high level of thermal mass, coupled with new wall insulation, allows temperature stability, even with an HVAC outage. The basement area can be used as a shelter during extreme events. The building is completely decoupled from the need for natural gas.

ENERGYFLOW Reducing Peak Electrical Demand. Electricity use of all building systems can be trended down to a five-second interval to allow for further tuning of system sequences. Introduction of ventilation air is staged over a longer period to flatten electrical demand during morning startup.

Reducing Plug Load. A tenant guide provides a list of preferred equipment, including laptops and ENERGY STAR-labeled devices. Plug load energy use is further controlled with smart plug strips tied into lighting occupancy sensor systems, and scheduled receptacles. Monthly reports of energy use for each tenant allow feedback on use of equipment.

Materials

The project reuses and restores available existing materials (historic doors, wood floors, plaster moldings, walls and ceilings). Materials and finishes have low-VOC content. Minimal exposure to chemicals and particulates is achieved with separate copy rooms and custodial areas, walk-off mats, and green housekeeping practices.
Hygrothermal analysis was used to ensure that the addition of new wall insulation would not have an adverse impact on existing masonry. This analysis accounts for the dynamic interaction of heat, air, and moisture transfer throughout a typical year. Thermostatic imaging also was used prior to the renovation to identify gaps in the building envelope and help shape an appropriate level of renovation.

Construction scheduling was dynamic, with a critical requirement to schedule and complete the appropriate level of renovation.

**LESSONS LEARNED**

**Measurement and Verification.** Develop a plan during schematic design and determine how access to building automation systems will be provided. For a federal project, security requirements can significantly impede access to data.

**Equipment Coordination.** Work closely with VRF system vendors to understand performance limitations and control specifics. The specified system for this project was not able to natively accommodate variable condenser water flow.

**Cooling Load Estimates.** GSA requires the use of prescriptive design assumptions for sizing HVAC and electrical systems. These design loads were significantly higher than measured. For a project where lighting and plug loads are carefully controlled, alternative system sizing approaches are required to avoid excess capacity, which can reduce system energy performance.

**Twinned VRF Systems.** A twinned heat pump unit consists of two modules sharing a common refrigerant connection to allow for greater connectedcool unit capacity. Compressor staging is not the same as with a typical heat pump system. It is better to use a greater number of single-unit modules to maximize the full load range of equipment. Note that standard AHRI testing does not account for real-world operating conditions: defrost cycles, site elevation, refrigerant piping length, and twinned unit operation are not readily reflected. If given the chance to approach the design again, the designers likely would not use twinned VRF systems or would use fewer twinned pairs, so a greater number of thermal zones would be on each unit.

**Temperature Setpoints.** Each thermal zone operates on a seasonal setpoint schedule, aligned with VRF system controls. Cooling is set to 72°F, and heating is 69°F to 72°F. It is important to have these settings in place before a tenant moves in. The building systems originally allowed a wider range of control; when settings were changed, some tenants were concerned about heating less control, even though values were within ASHRAE Standard 55-2010 comfort criteria. Consider thermostats without a digital readout of temperature.

**Wiring Systems.** While wetted wiring systems provide a high level of flexibility, reliable performance requires significant commissioning. The pairing sequence between receiver and transmitter (piezoelectric wall switches) is more challenging, because a common input signal is not transmitted. In a high masstransmission, system output can be further reduced.

**Proper Environmental Separation.** Having BAS graphics and interfaces developed for real-world operating conditions: defrost cycles, site elevation, refrigerant piping length, and twinned unit operation are not readily reflected. If given the chance to approach the design again, the designers likely would not use twinned VRF systems or would use fewer twinned pairs, so a greater number of thermal zones would be on each unit.

**Measurement and Verification.** Develop a plan during schematic design and determine how access to building automation systems will be provided. For a federal project, security requirements can significantly impede access to data.

**Equipment Coordination.** Work closely with VRF system vendors to understand performance limitations and control specifics. The specified system for this project was not able to natively accommodate variable condenser water flow.

**Cooling Load Estimates.** GSA requires the use of prescriptive design assumptions for sizing HVAC and electrical systems. These design loads were significantly higher than measured. For a project where lighting and plug loads are carefully controlled, alternative system sizing approaches are required to avoid excess capacity, which can reduce system energy performance.

**Twinned VRF Systems.** A twinned heat pump unit consists of two modules sharing a common refrigerant connection to allow for greater connectedcool unit capacity. Compressor staging is not the same as with a typical heat pump system. It is better to use a greater number of single-unit modules to maximize the full load range of equipment. Note that standard AHRI testing does not account for real-world operating conditions: defrost cycles, site elevation, refrigerant piping length, and twinned unit operation are not readily reflected. If given the chance to approach the design again, the designers likely would not use twinned VRF systems or would use fewer twinned pairs, so a greater number of thermal zones would be on each unit.

**Temperature Setpoints.** Each thermal zone operates on a seasonal setpoint schedule, aligned with VRF system controls. Cooling is set to 72°F, and heating is 69°F to 72°F. It is important to have these settings in place before a tenant moves in. The building systems originally allowed a wider range of control; when settings were changed, some tenants were concerned about heating less control, even though values were within ASHRAE Standard 55-2010 comfort criteria. Consider thermostats without a digital readout of temperature.

**Wiring Systems.** While wetted wiring systems provide a high level of flexibility, reliable performance requires significant commissioning. The pairing sequence between receiver and transmitter (piezoelectric wall switches) is more challenging, because a common input signal is not transmitted. In a high masstransmission, system output can be further reduced.

**Proper Environmental Separation.** Having BAS graphics and interfaces developed for real-world operating conditions: defrost cycles, site elevation, refrigerant piping length, and twinned unit operation are not readily reflected. If given the chance to approach the design again, the designers likely would not use twinned VRF systems or would use fewer twinned pairs, so a greater number of thermal zones would be on each unit.

**Measurement and Verification.** Develop a plan during schematic design and determine how access to building automation systems will be provided. For a federal project, security requirements can significantly impede access to data.

**Equipment Coordination.** Work closely with VRF system vendors to understand performance limitations and control specifics. The specified system for this project was not able to natively accommodate variable condenser water flow.

**Cooling Load Estimates.** GSA requires the use of prescriptive design assumptions for sizing HVAC and electrical systems. These design loads were significantly higher than measured. For a project where lighting and plug loads are carefully controlled, alternative system sizing approaches are required to avoid excess capacity, which can reduce system energy performance.

**Twinned VRF Systems.** A twinned heat pump unit consists of two modules sharing a common refrigerant connection to allow for greater connectedcool unit capacity. Compressor staging is not the same as with a typical heat pump system. It is better to use a greater number of single-unit modules to maximize the full load range of equipment. Note that standard AHRI testing does not account for real-world operating conditions: defrost cycles, site elevation, refrigerant piping length, and twinned unit operation are not readily reflected. If given the chance to approach the design again, the designers likely would not use twinned VRF systems or would use fewer twinned pairs, so a greater number of thermal zones would be on each unit.

**Temperature Setpoints.** Each thermal zone operates on a seasonal setpoint schedule, aligned with VRF system controls. Cooling is set to 72°F, and heating is 69°F to 72°F. It is important to have these settings in place before a tenant moves in. The building systems originally allowed a wider range of control; when settings were changed, some tenants were concerned about heating less control, even though values were within ASHRAE Standard 55-2010 comfort criteria. Consider thermostats without a digital readout of temperature.

**Wiring Systems.** While wetted wiring systems provide a high level of flexibility, reliable performance requires significant commissioning. The pairing sequence between receiver and transmitter (piezoelectric wall switches) is more challenging, because a common input signal is not transmitted. In a high masstransmission, system output can be further reduced.