2019 Advanced Home Upgrade

INSTALLATION SPECIFICATIONS

For Pacific Gas and Electric Territory

Version 4.0, April 1, 2019

Table of Contents

Contents

1 Introduction

Advanced Home Upgrade offers property owners incentives for participating in comprehensive, whole-house retrofits that are intended to give them greater comfort, savings on energy costs, and better indoor air quality. All projects conducted through the program must include Combustion Appliance Safety (CAS) testing. CAS testing must be conducted before and after the upgrade is completed ('Test-In' and 'Test-Out') and anytime work is done that impacts the pressure characteristics of the home (including air- and/or duct-sealing measures). All homes **must** pass CAS testing. Repairs or other corrective actions (as specified in the *Natural Gas Appliance Testing (NGAT) Action Guidelines* and *Whole House Combustion Appliance Safety Test Procedure For Pacific Gas and Electric Company [PG&E] Advanced Home Upgrade Program* documents) should be added to work scopes. Please manage expectations with customers accordingly.

The following is a brief overview of the Advanced Home Upgrade Program structure:

- Each Advanced Home Upgrade Program project provides customized work-scope solutions for each customer, which requires a minimum of four (4) installed energy efficiency 'upgrade' measures, including two (2) shell measures, one (1) HVAC measure and one (1) measure from any category, as well as installation or verification of the existence of at least one CO Alarm or Detector (see Section 2.2 below for specific requirement details). Two to four unit buildings are allowed to participate in Advanced Home Upgrade. Advanced Home Upgrade projects in PG&E service territory are administered by PG&E and implemented by Build It Green in all counties served by PG&E. For projects within BayREN counties[1], Advanced Home Upgrade projects must include High Performance HVAC Installation (HPHI) performed by a trained and approved participating contractor, with the following requirements : minimum of at least five (5) measures, including two (2) shell measures, two (2) HVAC measures ***and*** the High Performance HVAC Installation (Ultimate Comfort) measure. **Please Note**: Projects without HPHI would be submitted to BayREN's home upgrade program "Home+"[2] in BayREN counties.

This document provides a set of installation specifications for energy efficiency measures and/or health and safety tasks that are required for (or eligible for) inclusion in Advanced Home Upgrade projects. In addition, each upgrade must comply with (or exceed) national, state, and local laws and obtain required permits. The specification for each measure discusses minimum requirements, best practices, and may also include verification protocols for the Quality Assurance (QA) review verifier and Field Quality Control (FQC) verifier. The QA review verifier will apply the verification protocols to confirm that the minimum requirements were adequately met in 'desktop review' (after an application has been submitted for review for incentive processing). The FQC verifier will apply the verification protocols to confirm that the minimum requirements were adequately met in the field. The quality assurance and

[1] The 9 BayREN counties include: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma. For more information, visit www.bayren.org

[2] Information about the Home+ program can be found at www.bayrenresidential.org

quality control processes and the roles of the QA review verifier and Field Quality Control (FQC) verifier are discussed in more depth in the *Advanced Home Upgrade Participant Handbook.* [3]

The following energy efficiency measures may be selected to create an Advanced Home Upgrade rebate application and project work-scope:

Table 1. Advanced Home Upgrade Measures by CA Climate Zone[4]

Measure Description	Program Standard	Quantity	Customer Incentive CZs 1, 4, 11, 12, 13, 16	Customer Incentive CZs 2, 3, 5
Shell - Wall Insulation	R value ≥ 13 (2x4 framing) or R value ≥ 19 (2x6 framing), installed per CEC QII Standards.	Minimum 50% total wall area (all walls)	$500	$300
Shell - Attic Insulation	R-44 or better, installed per CEC QII Standards. Existing insulation maximum R19 in CZ 2, 3, 5. Existing insulation maximum R30 in CZ 1, 4, 11, 12, 13, 16.	100% of accessible attic area (minimum 50% of total attic area)	$500	$300
Shell - Floor Insulation	R value ≥ 19, installed to full-joist thickness, per CEC QII Standards.	100% of accessible floor area (minimum 50% of total floor area)	$500	$300
Shell - Whole building/envelope air sealing and ventilation	0.35 or better ACHn target, 0.5 ACHn minimum performance, achieved in accordance with BPI standards and ventilated per ASHRAE 62.2 (installation of balanced Heat Recovery Ventilation recommended) 1) 15% building leakage reduction (pre vs. post) 2) 30% building leakage reduction (pre vs. post)	800 square foot conditioned area (at 8 foot average ceiling height) minimum	$300 $500	$200 $300
HVAC - Replacement Ducts and Insulation	Replacement only; R-8 All CZs @ 5% leakage or less. Existing	100% of accessible ducts; up to 2 systems	$500	$500

[3] Advanced Home Upgrade Participant Handbook, homeupgrade.org/resources/documents

[4] CA Climate Zones, as defined by CEC's Title 24, energy efficiency standards glossary section, www.energy.ca.gov/maps/renewable/building_climate_zones.html

	ducts must be 10% leakage or greater to be eligible for upgrade.	per dwelling unit.		
HVAC - Cooling	Split AC: SEER 15.0/EER 12.5 or better Packaged AC: SEER 15.0/EER 12.0 or better	Up to 2 HVAC systems (total) per dwelling unit	$500	$300
HVAC - Heating	Sealed Gas Furnace: 92% AFUE or better Heat Pump: 9.0 HSPF or better		$500	$500
HVAC - Ultimate Comfort	Meet 7 Residential HVAC System Commissioning Specifications, including Delivered Sensible EER @ 85% or better (85% Delivered Heat for Furnaces); requires HVAC (cooling and/or heating) and Duct replacement measures and approved training in order to claim measure	One system per dwelling unit	$1000	$500
Gas Storage Water Heater	0.70 EF/UEF or better	Up to 2 DHWs (total) per dwelling unit	$300	$300
Condensing Gas Storage Water Heater	0.90 EF/UEF (sealed Combustion		$500	$500
Electric Storage Water Heater	3.24 EF/3.09 UEF or greater		$500	$500
Pool Pump	CEC Title 20 compliant variable speed pool pump replacing existing single or two-speed pump (primary in-ground pool system only; no jacuzzis)	One pool pump per project site	$500	$500
Smart Thermostat	EnergyStar certified Smart Thermostats. Must be Wi-Fi enabled and confirmed via test login.	Up to 2 per dwelling unit with corresponding HVAC system	$100	$100
Lighting	$5 per pin-base recessed LED retrofit fixture (Title 24 - JA8 Compliant)	Up to 25 per dwelling unit	$125	$125
Per-Project Maximum			**$5,500**	**$3,500**

Qualifications for different measures are dependent on PG&E provided utility services, as follows:

- **All electric**: PG&E all electric customers with no PG&E gas qualify for all electricity-related measures (no propane fuel measures)
- **PG&E electric**: Customers receiving electricity from PG&E qualify for all electricity-related measures
- **PG&E gas**: Customers receiving gas from PG&E qualify for all natural gas fuel-related measures
- **SoCalGas**: Customers receiving electricity from PG&E and natural gas from SoCalGas only qualify for electricity-related measures
- **Other providers**:
    - Customers receiving electricity from PG&E but gas from another provider qualify only for electricity-related measures
    - Customers receiving gas from PG&E but electric from another provider qualify only for natural gas fuel-related measures

Customers who receive both gas and electric service from PG&E are eligible for all of the Advanced Home Upgrade measures listed above. Customers who only receive one type of fuel from PG&E are eligible for rebates for any equipment (primary systems only, back-up systems are not eligible for incentives) selected as part of the combined measures, as long as PG&E supplies the fuel for it. Upgrading an existing appliance, water heater or HVAC-equipment from electric to gas or gas to electric, called 'fuel-switching', is not eligible for a rebate in Advanced Home Upgrade due to statewide rules set by the CPUC. Upgrades of existing equipment must be for more efficient versions of the same type of equipment (i.e., less-efficient Gas Central Furnace to more-efficient Gas Central Furnace, etc.). Additionally, customers must have existing non-portable air-conditioning and/or existing non-portable electric heating if they only have PG&E electric service **or** an existing non-portable natural gas furnace if they only have PG&E gas service, regardless of whether that equipment is selected as a measure as part of an Advanced Home Upgrade incentive application.

QA review for all projects will include confirmation of work-scope and verification via photo documentation of existing and upgraded installations of incentive measures selected with the application. QA review will also verify the existence of at least one permit pertaining to the project's measures (signed and closed for HVAC), as most measures require permits to be obtained from local code enforcement or building departments.

2 Non-Incentive Program Requirements

2.1 Combustion Appliance Safety Testing

2.1.1 Minimum Requirements

- Combustion appliance safety testing must be conducted or supervised by a BPI-certified professional with PG&E Advanced Technical Training (including PG&E's Make Safe Procedure) anytime work is done that impacts the pressurization of the home (including infiltration measures). In particular, this procedure is to be performed both before and after the installation of any air sealing measures.
- All CAS (combustion appliance safety) and CAZ (combustion appliance zone) testing must be done in accordance with the testing protocols in the *Whole House Combustion Appliance Safety Test Procedure for Pacific Gas and Electric Company (PG&E) Advanced Home Upgrade Program*. Contractors must make repairs or take other corrective actions as specified in the *Natural Gas Appliance Testing (NGAT) Action Guidelines*.[5]
- For buildings with 2-4 units, each unit and each CAZ must be tested, with particular attention paid to the possibility of pressure 'communication' between units.

2.1.2 Best Practices

- Focus on older appliances that need to pull air out of the house to operate safely (natural draft combustion appliances). Sealed combustion or direct-vent combustion appliances only need to be tested for ambient CO in the vicinity of the appliance if they are properly installed.
- Each zone is a separate set of circumstances, and must be brought to its most-negative depressurization.
- Assumed 'All Electric' homes must still be inspected for combustion appliance and tested for ambient CO as a precaution. They also require CO monitors as building uses can change and they can be affected by temporary CO hazards.
    1. Install 'jump ducts' or transfer grills which allow air to flow more freely into and out of rooms when the HVAC system is operating. If opening the door to any given room reduces the depressurization of the CAZ, this strategy can be effective. With jump ducts or transfer grills, the same improvement can be achieved without the need to leave that room's door open.
    2. Design and install two independent paths for combustion ventilation air (CVA) to reach the appliance zone directly from outdoors. Then air-seal and insulate these paths, and also insulate and air seal the appliance zone itself.
    3. Enlarge the combustion appliance zone by removing obstructions like interior partitions and doors, so that air can flow freely into the zone from other parts of the house.
- Appliance replacement (from natural draft to Sealed Combustion) is usually the most practical and least expensive. It provides energy savings plus safe operation.

[5] Available at www.builditgreenutility.org/document-library

- If combustion appliance testing reveals that there is spillage of combustion gases (i.e., not enough flue draft pressure in the vent of the appliance), there are a few potential choices that can help remedy the issue:
    4. Replace the appliance with a modern sealed-combustion unit.
    5. Remove and reinstall the combustion appliance outside of the home's pressure boundary (usually to the garage or attic) or entirely 'outdoors'.
    6. Add jump-ducts or transfer grills between 'compartmented spaces' to reduce the pressure differences created when the HVAC system's blower is operating. (Compartmented spaces are rooms with doors, but without an air outlet to relieve pressures created by the HVAC system.)
    7. Add more CVA to the area where the appliance is located (the combustion appliance zone).
- Of these alternatives, appliance replacement with sealed combustion units is by far the preferred alternative. It saves energy through much-increased heating efficiency and provides an opportunity for further energy-saving synergies with other heating and cooling components.

2.1.3 Verification

- FQC verifiers will be assessing the effectiveness of the work performed and determine if all efforts had been made to mitigate health and safety hazards.
- Combustion safety is of utmost concern. FQC verifiers will be testing all CAZ areas as well as the appliances for combustion safety per BPI and PG&E's *Natural Gas Appliance Testing (NGAT) Action Guidelines*.

2.2 Carbon Monoxide Device

2.2.1 Minimum Requirements

- Carbon monoxide (CO) devices (alarms or detectors) are appropriate wherever there is a CO hazard and/or dwelling unit.
- As required for compliance with CA SB-183 (also known as the "Carbon Monoxide Poisoning Prevention Act"), as of July 1, 2011, all Program Single-Family Dwelling projects, regardless of necessity for building permit, must include permanent installation of at least one CO alarm/detector meeting UL-2034 (for alarms) or UL-2075 (for detectors), installed according to manufacturer's instructions (and NFPA 720) in all dwelling units intended for human occupancy. This includes 'all-electric homes', as dwelling unit uses can change or encounter temporary/event-specific CO hazards. Existing alarms/detectors less than five years old and meeting Program requirements are allowed. 2-4 Unit Dwelling projects are also required to comply (as of January 1, 2013). CO Monitors must be installed outside each sleeping area, including the basement (if applicable).
- Instructions and paperwork including service and maintenance of the unit shall be provided to customers.
- CO devices shall be replaced every five years or less.

2.2.2 Best Practices

- In addition to installing CO devices outside of sleeping areas (typically in hallways near bedrooms), it is recommended that additional CO devices are installed to provide a separate detector(s) for each floor of the building, in areas with atmospherically vented appliances, in kitchens, and near doors to attached garages (see *Participant Handbook* for additional details and resources).

2.2.3 Verification

- FQC verifiers will conduct field compliance verification for installation of carbon monoxide devices.

2.3 Participant Health & Safety

2.3.1 Minimum Requirements

- All Participating Contractors and Independent Building Analysts must abide by BPI Health and Safety standards and have all the necessary personal safety equipment required by all applicable federal, state and local laws, including, but not limited to, the "Occupational Safety and Health Standards" promulgated by the U.S. Secretary of Labor and the California Division of Occupational Safety and Health (OSHA and CalOSHA, respectively).[6] Required safety equipment includes, but is not limited to:
    - Canister-type respirators
    - Gloves
    - Protective clothing or overalls
    - Elbow and knee pads
    - Safety glasses
    - Hard hats
    - First aid kit
    - Fall arresters
- Technicians and installers must be trained on the proper use and applicability of these safety devices and adhere to all OSHA regulations when performing diagnostics or work at the site.
- All tools and machinery must be used in a safe manner and be properly maintained and/or calibrated per manufacturer's recommendations.
- Diagnosticians and installers must have in their possession all applicable GHS-compliant SDS Sheets for all materials brought on site. This includes but is not limited to:

[6] OSHA: Code of Federal Regulations, 29 CFR, Part 1910, *Occupational Safety and Health Standards*, and Part 1926, *Safety and Health Regulations for Construction*, U. S. Department of Labor, Occupational Safety and Health Administration, www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=0 Cal/OSHA: Laws and Regulations, Department of Industrial Relations, State of California, www.dir.ca.gov/dosh/LawsAndRegulations.htm

- Diagnostic smoke
- Caulking and adhesives
- Insulation and air-sealing materials

- If there is known or suspected presence of lead, mold, asbestos, or any other perceived or potentially hazardous materials found at test-in/initial assessment or at any time during or after installation, all care must be taken to ensure occupant and worker safety. Site-specific judgement should be utilized to determine whether it is safe to perform blower-door and/or duct-testing on a case-by-case basis. All applicable codes, ordinances, and guidelines must be followed.
- Training and certification in the identification, removal, disposal, abatement and remediation of hazardous materials is outside of the scope of the Program. If any hazardous materials are encountered during the course of a project, only those Participating Contractors that have the necessary training and required certification(s) and/or license(s) may remove, dispose, abate and/or remediate hazardous materials discovered on a job site. Participating Contractors, and/or their appropriately licensed subcontractors, shall be solely responsible for their identification, removal, disposal, abatement and/or remediation of hazardous materials encountered on a job site. Neither Build It Green nor PG&E shall have any liability arising out of, resulting from or regarding a Participating Contractor's (and/or their subcontractors') detection, identification, inspection, removal, disposal, abatement, and/or remediation of hazardous materials.

2.3.2 Best Practices

- In addition to complying with all OSHA, Cal/OSHA and all other applicable federal, state and local laws health and safety laws and standards, program participant employees should participate in OSHA 10-Hour or 30-Hour, HAZWOPER, First-Aid, AED and/or CPR trainings (see *Participant Handbook* for additional details and resources) and update trainings regularly or as needed.

2.3.3 Verification

- FQC verifiers will conduct field compliance verification for the presence of project-site safety issues and/or hazards, and may also request copies of applicable GHS-compliant SDS Sheets.

3 Advanced Home Upgrade Incentive Measures

3.1 Air Sealing

Per BPI, an effective and continuous thermal and pressure boundary shall be established in each home through the installation of appropriate air sealing and insulation measures. Wherever possible, air sealing and insulation strategies shall be designed to align the thermal and pressure boundaries to create a single continuous thermal envelope.

Air sealing strategies shall be determined based on blower door diagnostic results, visual inspection of critical bypass areas, and indoor air quality evaluations for each home.

3.1.1 Minimum Requirements

- All air sealing shall be performed before installation of insulation.
- The air sealing target is to get below 0.35 air changes per hour, natural (ACHn), but at a minimum, achieve 0.50 ACHn or better (lower) with a 15% or 30% (or better) improvement in building leakage reduction pre- vs. post-installation.
- All projects must comply with Indoor Air Quality and Mechanical Ventilation requirements in Section 4.6 of the *Residential Compliance Manual for the Building Energy Efficiency Standards*, Title 24, Part 6 [7] (including local exhaust ventilation or local exhaust ventilation and continuous mechanical whole-house ventilation in accordance with ASHRAE 62.2-2010 [CA]).
- Whole house air sealing to reduce air infiltration shall be done in accordance with
    - Building Performance Institute (BPI) Standards as follows:[8]
    - Air sealing measures shall be prioritized to reduce the stack effect and inhibit moisture migration into attics or other interstitial spaces.
    - Blower door quick tests should be performed during air sealing to track progress and verify results.
    - Garage to living space connections should be tested for air tightness using a smoke stick or pressure measurements in conjunction with the blower door. Air leaks between the garage and living space should be sealed as part of the work scope.
    - Attic ventilation shall not be recommended or installed without first verifying the presence of an effective air barrier and thermal barrier between the attic and the living space or specifying appropriate attic air sealing as part of the work scope.
    - Air seal communication between the attic and living space first. Areas to seal include, but are not limited to: bypasses around chimneys, ducts, drop soffits, shower inserts or other large penetrations, interior and exterior wall top-plates, and plumbing and wiring penetrations.
    - Leakage paths identified between attached or tuck-under garages and the living space must always be sealed.
    - Seal off leakage paths through interstitial building cavities using manual air sealing, high-density cellulose cavity insulation (see below), or spray-foam products.

[7] California Energy Commission, www.energy.ca.gov/title24

[8] Building Performance Institute, *www.bpi.org/standards_approved.aspx*

- If the home's CFM50 is still higher than 0.5 ACHn after sealing the attic, garage, and basement, interior air-sealing may be performed as needed including: sealing around plumbing penetrations, caulking around window and door casings, caulking around molding and baseboards, or other significant leakage areas identified using the blower door.
- Air-sealing installations should be performed to be permanent improvements to the structure. Products with an expected lifespan of less than 20 years should not be used.
- A blower door test (required for Advanced Home Upgrade 'test-out' if Whole Building Air Sealing measure was selected) and combustion appliance safety (CAS) test must be performed before and after the installation of air sealing (each day if necessary) to ensure safety and when a mechanical ventilation system is installed in a building where combustion appliances are present. All CAS tests must include testing to meet minimum safety requirements for draft, spillage, and CAZ depressurization.

3.1.2 Best Practices

- Although the Program target is 0.35 ACHn, a better practice is to air seal as much as possible (ideally, target 0.14 ACHn or 3 ACH50, as a best practice) to reduce energy loss and to mitigate unwanted pollutants from entering the home (target at least 15% leakage reduction, but best practice would be to target 30% leakage reduction or better). This level of effort (below 0.35 ACHn) would need to include installation of a separate 'whole building' mechanical ventilation system for the home per ASHRAE 62.2, which would provide sufficient ventilation air for the occupants due to a tighter building envelope. As a best practice, this would be a balanced or Heat Recovery Ventilation (HRV) system with high-efficiency Electronically Commutated Motor (ECM) driving the fan. Customers should be made aware of this potential outcome. Although this strategy may intuitively seem in contradiction to logic and program goals (i.e., saving energy), the research has shown that most often tighter structures with high-efficiency mechanical ventilation systems save more energy than leaky structures without mechanical ventilation.
- Even when the building envelope is not sealed below 0.35 ACHn or an addition of conditioned living area does not trigger required installation of continuous mechanical ventilation per ASHRAE 62.2-2010 (CA), it would be a best practice to provide continuous mechanical ventilation anyway, ideally utilizing balance mechanical ventilation via an HRV system.
- Zonal pressure diagnostic testing should be performed to identify those areas of the structure that have the most air leakage. Typically, the high areas of the home (ceiling plane of top floor) have the most cost-effectiveness due to the "stack-effect" (heat rising and leaving the structure). Penetrations in the ceiling plane, including light fixtures, exhaust fans, speakers, and attic hatches, should be sealed as accessible with the appropriate materials. Non-insulation rated recessed light fixtures could/should be replaced with ICAT (insulation contact, air-tight) type fixtures. If insulation is to be added on top of, and/or otherwise in-contact with, recessed light fixtures, non-insulation rated recessed light fixtures shall be replaced with ICAT recessed light fixtures.
- Air sealing around vent stacks and chimneys may need special care. Some of these pipes and vents can get very hot; therefore, only heat resistant materials should be utilized, including heat-resistant caulking and/or foam sealants that are rated for this purpose.

- Consider low-VOC content materials whenever possible for the health of your crews and the occupants.

Using Insulation for Air Sealing:

- Where leakage paths are identified that cannot be accessed or reasonably sealed using conventional air sealing techniques, high-density cellulose or foam insulation can be installed strategically to reduce airflow through the building shell.
- If cellulose insulation is to be used as an air barrier in an enclosed cavity, it must be installed at a minimum density of 3.5 pounds per cubic foot.
- Fiberglass insulation is not an air barrier and may never be used as an air sealing material.

3.1.3 Verification

- QA review will include confirmation of work-scope and photo documentation of pre- and post-upgrade building leakage testing results (manometer photos). The contractor shall report test-in and test-out blower door results for appropriate building leakage reduction measure targets to the Program in CFM50.
- The FQC verifier's test results should be within rounding error (0.5 percent) of the reported test-out (post-upgrade) numbers.
- FQC verifiers will be assessing the effectiveness of the work performed and determine if all reasonable efforts had been made to mitigate accessible uncontrolled infiltration and to provide mechanical ventilation (as needed or required).

3.2 Attic Insulation

According to BPI Shell Standards, prior to installing insulation in an existing home, a thorough inspection of the interior and exterior of the home is required to identify areas where installation of insulation may be unsafe. Problem areas include: areas with knob-and-tube wiring, recessed light fixtures, areas where moisture is present or suspected, and structurally unsound building elements (e.g., suspended acoustical tile ceilings, wood paneling). Problems that are identified must be communicated to customers in writing and should be remedied prior to insulating.

3.2.1 Minimum Requirements for Insulation

- Documented, pre-existing insulation levels cannot exceed R-19 in CZ 2, 3, and 5 or R-30 in CZ 1, 4, 11, 12, 13, and 16. Installed insulation must be new material, installed to R-44 or better, and meet or exceed all applicable local, state, and federal standards and code requirements.
- Insulation must be installed in the attic and/or thermal boundary of the conditioned living area.
- CAS and blower door testing shall be performed whenever insulation, air sealing, or ventilation is installed to confirm safe conditions for the occupants.
- Newly installed insulation must benefit the occupant(s). Insulation should be installed between a conditioned living area and all accessible, unconditioned, non-living area. Installing insulation

in building assemblies with minimal or no potential for heat transfer (i.e., garage ceiling to vented attic, interior ceiling [1st story] to interior floor [2nd story], etc.) does not qualify.

- Materials shall comply with, and be installed in conformance with, all applicable local, state, and federal building and fire codes, including, but not limited to, compliance with flame spread rating and smoke density requirements of Title 24, Part 2, Chapter 7, Section 720, Thermal- and Sound-Insulating Materials.[9]
- Insulation shall not be installed where live knob-and-tube wiring exists, unless wiring has been surveyed by a C-10 electrical contractor and certified to be acceptable for encapsulation and communicated to the customer in writing. Whenever possible, upgrade wiring to current standards before insulating.
- Materials shall be certified to be in compliance with California insulation quality standards, as listed in the current *Directory of Certified Insulation Materials*.[10]
- All attic access openings, including doors, hatches, and pull-down stairs shall have a tightly fitting cover which is insulated to a minimum R-30 (preferably, the same R-value as the upgraded attic insulation). Permanently attach rigid foam or batt insulation to the access door using adhesive or mechanical fastener. The bottom of the attic access shall be properly gasketed to prevent air movement.
- R-values of installed insulation shall be determined based on an actual measurement of the insulation depth and the R-value per inch for that product. Refer to *Building Performance Institute Technical Standards for the Building Analyst Professional* for typical insulation R-values and effective R-values for batt insulation.[11] For Advanced Home Upgrade, voids in insulation must be accounted for by determining the net square footage of uninsulated area and recording it as a separate building assembly/component orientation of the building.
- Insulation shall cover all recessed lighting fixtures. If recessed light fixtures are not rated for insulation cover (IC) and air tight (AT), the fixtures should be replaced.
- All recessed light fixtures that penetrate the ceiling shall be IC (insulation contact) and AT (air tight) rated and shall be sealed with a gasket or caulk between the housing and the finished surface or, if not IC rated, recessed light fixtures must be "boxed-in" with approved fire-rated materials (i.e., fire-rated drywall "boxes", "fire-boxes", etc.) and air-sealed with fire-rated caulk or blocked with non-combustible material to maintain safe clearance to insulation. Other heat-producing devices (e.g., exhaust fans, etc.) must be ICAT rated or high-efficiency ECM motor-driven so that it will not get hot enough to be eligible to be IC tested and listed, per manufacturer equipment documentation. Chimneys, flues and other "hot vents" must also be baffled with an effective non-combustible dam or blocking prior to insulating to maintain a safe clearance to the insulation being installed. Refer to Title 24 for specific clearance requirements and consult local code enforcement for any additional clearance requirements.
- Single-walled flue pipes require a minimum 6-inch clearance to insulation or other combustible materials. Refer to NFPA 54 for additional requirements for specific chimney materials. Hard

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[9] California Building Standards Commission, *California Building Standards Code: California Code of Regulations Title 24, www.dgs.ca.gov/BSC/Codes*

[10] State of California Department of Consumer Affairs, *Consumer Guide and Directory of Certified Insulation Material,* bhgs.dca.ca.gov/industry/thermal_insulation.shtml

[11] Building Performance Institute, www.bpi.org/standards_approved.aspx

covers or draft stops shall be placed over all drop ceiling areas and interior wall cavities to keep insulation in place and stop air movement. If hard covers or draft stops are missing or incomplete, they shall be completed before insulation is installed.

- Required eave ventilation shall not be obstructed—the 'net-free' ventilation area of the eave vent shall be maintained. Eave vent baffles shall be installed to prevent air movement under or into the insulation.
- Materials shall be installed according to manufacturer specifications and instructions.
- Protect the installing crews by providing safety gear (dust masks and protective clothing), ample light, and fresh air to the space they are working in.

3.2.2 Best Practices for Attic Insulation

- Air sealing (all accessible areas) should be performed before insulation is installed.
- Installation of insulation should be done in accordance with Building Performance Institute (BPI) Standards[12] and California Quality Insulation Installation Standards (QII), as specified in
    - the Building Energy Efficiency Standards Reference Appendices, Section RA3.5.[13]
- To prevent deficiencies in the thermal boundary (insulation layer), it is considered best practice to refrain from batt-type insulation products in the attic, above the ceiling plane. It is recommended to use blown-in products such as blown-in fiberglass or cellulose.
- All care should be taken to minimize dust and insulation materials from entering the living space. There are different ways to resolve this: one is to create separate entrances into the attic space outside of the living space such as through a gable-end vent or skylight shaft; or, if that is not possible, at least keep a controlled pathway through the home that minimizes dust transfer into living space. Another strategy is to positively pressurize the living space to prevent migration of dust particles into the living space.
- Attic insulation should not be recommended or installed without first verifying the presence of an effective air barrier between the attic and living space or specifying appropriate attic air sealing as part of the work scope. To evaluate the effectiveness of the attic-to-living space air barrier, various techniques can be used such as:
    - Pressure differential diagnostics, series leakage tests, and "add a hole".
    - Visually inspecting the attic floor underneath the insulation layer to locate air bypasses and cavities.
    - Inspecting the current insulation material for signs of infiltration (soot-blackened).
    - Using a smoke stick with a blower door running in the conditioned space to see if the smoke is drawn down into the living space.
    - Reversing the blower door (pressurizing) and conduct Infrared investigation from the attic-side of the ceiling to see if heat transfer is occurring.

[12] Building Performance Institute, www.bpi.org/standards_approved.aspx

[13] California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards, Title 24, Part 6*, www.energy.ca.gov/title24

If there is air movement identified by one of the above methods, those areas should be addressed as part of the work scope prior to insulation being installed.

- Attic crawl space should be adequate (ideally, 24 inches or more between the bottom of the roof rafter and the top of the ceiling joists) and accounted for, depending on the type of insulation being installed

When requested or available, specify environmentally preferable materials:

- **Cellulose, Cotton, Wool:** Minimum 75 percent post-consumer recycled content as recommended by EPA's Recovered Materials Advisory Notice (RMAN) [14] *and* demonstrated low-emitting as defined by California's Section 01350.[15]
- **Fiberglass:** Minimum 20 percent recovered (pre or post-consumer recycled) content as recommended by EPA's Recovered Materials Advisory Notice (RMAN) *and* demonstrated low-emitting as defined by California's Section 01350.
- **Spray Foam:** Demonstrated low-emitting as defined by California's Section 01350. Recommended minimum five percent recovered (pre-or post- consumer) recycled content or agriculture- based content as recommended by EPA's Recovered Materials Advisory Notice (RMAN).

3.2.2.1 *Standards for Insulating Knee walls*

- All knee walls and skylight shafts should be insulated to a minimum of R-19. If loose-fill insulation is used it shall be properly supported with netting or other support material.
- The insulation should be installed without gaps and with minimal compression.
- The house side of the insulation should be in continuous contact with the back of the drywall (air barrier) or other wall finish.
- The insulation shall be supported so that it will not fall down by either fitting to the framing, stapling in place with minimal compression, or using other support such as netting.
- Walls of interior closets for heating ventilation and air conditioning (HVAC) and/or water heating equipment, which require combustion air venting, should be insulated to the same R-value as the exterior walls.
- Insulation installed in knee-walls or other exposed vertical areas within an attic must be covered on the cold side with an air barrier such as ½-inch plywood, 5/8-inch drywall, FSK, or other air-sealing, fire-rated material to protect the insulation from wind-washing and prevent convection within the insulation. This measure is not necessary if rigid foam insulation is used. Local codes might also require fireproofing of those vertical surfaces on the attic side.

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[14] Environmental Protection Agency, *Comprehensive Procurement Guidelines for Construction Projects*, www.epa.gov/smm/comprehensive-procurement-guidelines-construction-products

[15] CalRecyle, Green Building Special Environmental Requirements, *Section 01350*, www.calrecycle.ca.gov/greenbuilding/specs/section01350 and California Department of Public Health, *Indoor Air Quality (IAQ) Section*, www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHLB/IAQ/Pages/VOC.aspx#material

3.2.2.2 *Standards for Batt Insulation*

- Batt insulation should be installed at full loft with the insulation in full contact with the warm side of the building surface. Gaps between the insulation and the building elements must be avoided. Insulation batts should not be compressed, folded, tucked, rolled, or otherwise compromised when installed for insulation purposes.
- Batts should be correctly sized to fit snugly at the sides and ends. Batts should be installed so that they will be in contact with the air barrier. Where necessary, batts should be cut to fit properly - there should be no gaps, nor should the insulation be doubled-over or compressed.
- Batts shall be cut to butt-fit around wiring and plumbing, or be split (delaminated) so that one layer can fit behind the wiring or plumbing, and one layer fit in front.
- For batts that are taller than the trusses, full-width batts should be used so that they expand to touch each other over the trusses.

3.2.2.3 *Standards for Loose-Fill Ceiling Insulation*

- Insulation should be blown to a uniform thickness throughout the attic at appropriate air pressure and material quantity (depth and/or weight) to ensure complete coverage and manufacturer's recommended density to achieve the prescribed R-value without voids, gaps, or settling in enclosed cavities. Insulation should be applied all the way to the outer edge of the wall top plate.
- Attic rulers appropriate to the material installed shall be evenly distributed throughout the attic to verify depth: one ruler for every 250 square feet and clearly readable from the attic access in all directions. The rulers shall be scaled to read inches of insulation and the R-value installed.
- Insulation should be applied underneath and on both sides of obstructions such as cross-bracing and wiring.

3.2.2.4 *Standards for Spray Foam Insulation*

Spray foam insulation (SPF) increases thermal performance and reduces air infiltration significantly. SPF insulation has a number of application-specific requirements. When it is used, all work should conform to California regulations as specified in Building Energy Efficiency Standards Reference Appendices, Section RA3.5.6: [16]

- SPF insulation should be spray-applied to fully adhere to the substrate (roof deck or ceiling).
- SPF insulation should be spray-applied to fully adhere to the joist and other framing faces to form a complete air seal within the construction cavity.
- SPF insulation should be installed in a continuous and fully adhered manner to form an air barrier.
- SPF insulation should be spray-applied to fully adhere to and seal around wiring and plumbing.
- SPF insulation should not be applied directly to recessed lighting fixtures unless IC rated appropriate for use with polyurethane spray foam in accordance with NEMA LE 7-2015.

[16] California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards, Title 24, Part 6*, www.energy.ca.gov/title24

Recessed light fixtures that are not insulation contact (IC) rated should either be replaced or eliminated. If they are not replaced or eliminated, they may be covered or "boxed-in" if they meet the criteria in Building Energy Efficiency Standards Reference Appendices, Section 3.5.6.3.

HVAC Platform

- A minimum of 3 inches of SPF insulation should be placed below any plywood platform or cat-walks installed in vented attics for HVAC equipment and access to assure that the overall assembly meets the required insulation values listed in the compliance documentation.
- SPF insulation should be installed in a continuous and fully adhered manner to form an air barrier.

Attic Access

- Apply a minimum of 3 inches of SPF insulation to the access door or permanently attach rigid foam with adhesive or mechanical fastener to assure that the overall assembly meets the required values specified in the Compliance Documentation.

Attics and Cathedral Ceilings

- Prior to installation, verify that the building official in your area permits SPF insulation directly applied to the underside of the roof.
- SPF insulation shall be kept away from combustion appliance flues in accordance with flue manufacturer's installation instructions or labels on the flue for clearance.
- In unvented-conditioned attics where entry is made for the service of utilities, SPF applied in direct contact with the underside of the roof deck shall be protected from ignition in accordance Building Energy Efficiency Standards Reference Appendices, Section RA3.5.6. [17]
- In cathedral ceilings where restricted spaces do not allow entry, SPF insulation does not require protection from ignition.

3.2.3 Verification

- QA review will include confirmation of work-scope and photo documentation of existing and upgraded insulation installations (insulation coverage and/or R-Values, rulers and 'installed location context' photos).
- Field QC verifications will visual verification of installed levels and presence/location of rulers and may include invoice review and/or measuring random points within the attic and comparing installed levels to insulation charts showing R-values for the different types of insulation.
- The location of insulation and how well it serves the occupants will be assessed.
    - Insulation installed in areas with no comfort or energy saving benefit does not qualify.
- Attic access hatches shall also be evaluated for their insulation effectiveness.

[17] California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards, Title 24, Part 6*, www.energy.ca.gov/title24

3.3 Wall Insulation

3.3.1 Minimum Requirements

- Installation shall conform to all applicable (i.e., where not 'attic-specific') items in the list of Minimum Requirements for Insulation specified in Section 3.2.1 of this document.
- Wall insulation shall achieve R-13 or greater (2x4 framing); R-19 or greater (2x6 framing).
- Insulation is installed full-stud thickness regardless of material used.
- Insulation should cover all-accessible (at least 50 percent of total) wall area. Additionally, the existing insulation installation-available wall area must exceed 50 percent of the total wall area in order to claim that upgrade measure.
- Where accessible, wall stud cavities should be caulked or foamed to provide a substantially air-tight envelope to the outdoors, attic, garage, and crawl space. Special attention should be paid to plumbing and wiring penetrations through the top plates, electrical boxes that penetrate the sheathing, and the sheathing seal to the bottom plate. All gaps in the air barrier greater than 1/8 inch should be caulked, or sealed with expansive or minimally expansive foam.
- Installation should uniformly fill the cavity side-to-side, top-to-bottom, and front-to-back.

3.3.2 Best Practices

- Batt insulation products should be installed with care. This type of insulation product is the most susceptible to 'human error' and may not perform well if not installed properly. Loose-fill insulation products are better at avoiding deficiencies in quality while installing the product.
- Have all insulation installation work third-party verified for quality and level (QII).
- Thermal imaging cameras can be utilized to provide insight into the quality and thoroughness of the installed wall insulation.

3.3.2.1 *Standards for Batt Insulation*

- Insulation should be fitted and cut around pipes, wires, etc. that may be traversing the bay. The batt should be split so that equal amounts of insulation are in back of and in front of those items. Ideally, nothing is viewable after insulation is installed except for the insulation product itself.
- The batt should be friction fitted into the cavity unless another support method is used.
- Batt insulation should be installed to fill the cavity and be in contact with the sheathing on the back and the wallboard on the front – no gaps or voids.
- Non-standard-width cavities should be filled with insulation fitted into the space without excessive compression.
- Batt insulation should be cut to butt-fit around wiring and plumbing, or be split (delaminated) so that one layer can fit behind the wiring or plumbing and one layer fit in front.

3.3.2.2 *Standards for Loose-Fill Insulation*

- Loose-fill insulation, whether it is fiberglass or cellulose, can be installed behind netting, which is stapled to the fronts of studs. If moisture is added to cellulose or adhesives added to fiberglass, the product could be installed without netting.
- CAUTION: Moisture levels in insulation must be carefully monitored before installing sheet goods. If the walls are closed up too soon, moisture could affect interior of walls and cause durability issues.
- Loose-fill insulation should be installed to fill the cavity and be in contact with the sheathing on the back and the wallboard on the front – no gaps or voids.
- Loose-fill wall insulation should be installed to fit around wiring, plumbing, and other obstructions.
- For QII, the installer shall certify on the Installation Certificate forms that the manufacturer's minimum weight per-square-foot requirement has been met.

3.3.2.3 *Standards for Spray Foam Insulation*

- Spray foam insulation may be used in walls to decrease air infiltration and add thermal performance to the wall assembly.
- Installation should comply with Building Energy Efficiency Standards Reference Appendices, Section RA3.5.6 [18]
- In wall cavities, SPF insulation should be applied to provide an air-tight envelope to the outdoors, attic, garage, and crawl space. Special attention shall be paid to plumbing and wiring penetrations through the top plates, electrical boxes that penetrate the sheathing, and the sheathing seal to the bottom plate.
- SPF insulation installation should uniformly cover the cavity side-to-side and top-to-bottom. An air space may be left between the surface of the Medium-Density SPF insulation and the interior sheathing/drywall, provided the appropriate thickness of SPF insulation has been applied to achieve the specified R-value and the SPF insulation is installed to cover and form an air barrier on the framing at the top, bottom, and sides of each cavity.
- Narrow spaces (2 inches or less) at windows and door jambs should be filled with minimally expansive foam.
- Narrow spaces (2 inches or less) between studs at the building corners and at the intersections of partition walls should be filled with batt insulation snuggly fitted into the space (without excessive compression), loose-fill insulation, or expansive or minimally expansive foam.
- SPF insulation should be spray-applied to fully adhere and seal around wiring and plumbing.
- SPF insulation should be spray-applied to fully seal between the sheathing and the rear of electrical boxes and phone boxes.
- In cold climates, where water pipes may freeze (including Climate Zones 14 and 16), pipes should have at least two thirds of the insulation between the water pipe and the outside. If the pipe is near the outside, as much insulation as possible shall be placed between the pipe and the

[18] California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards, Title 24, Part 6*, www.energy.ca.gov/title24

outside and no insulation (minimal amounts of SPF overspray are acceptable) shall be allowed between the pipe and the interior wall.

3.3.3 Verification

- QA review will include confirmation of work-scope and photo documentation of existing and upgraded insulation installations (insulation coverage and/or R-Values and 'installed location context' photos, if available). Thermal imaging photo confirmation (pre- and post-installation) may be requested for wall insulation projects, as needed.
- FQC verification will include visual inspection and comparing installed levels to insulation charts showing R-values for the different types of insulation, invoice review, and/or thermal imaging.
- The location of insulation and how well it serves the occupants will be assessed.
    - Insulation installed in areas with no comfort or energy saving benefit does not qualify.

3.4 Floor Insulation

3.4.1 Minimum Requirements

- Installation shall conform to all applicable (i.e., where not 'attic-specific') items in the list of Minimum Requirements for Insulation specified in Section 3.2.1 of this document.
- Insulation should be installed full-joist thickness regardless of material used.
- Insulation should not be installed in floors separating unconditioned areas from unconditioned areas.
- Floor insulation should be brought up to R-19 at a minimum (including floor access hatches).
- Floor insulation should cover all-accessible (at least 50 percent of total) floor area.
- All floor insulation work must follow local, state, and federal guidelines and code requirements specifically around ventilation and vapor barriers.

3.4.2 Best Practices

- Consider locating under-floor insulation to perimeter of crawl space walls in lieu of under floor in areas where HVAC distribution systems are located under the home. This is considered a 'sealed crawl space' and many rules are triggered by this method that must be followed (for more information contact Build It Green at 510-285-6222).
  Loose-fill insulation may be installed in floors (with caution). Cellulose insulation may not be the best choice because of its absorptive properties. It may be best to use fiberglass products when insulating floors over a crawl space. Spray Foam insulation used under floors is a great way to accomplish air-sealing and thermal enhancement to an underperforming floor assembly. Consult with reputable spray foam insulation installers when selecting high or medium density foam products and where they will be used.
- Ensure that worker safety is top priority when applying any insulation products.

3.4.2.1 *Standards for Batt Insulation*

- Insulation should be fitted and cut around pipes, wires, etc. that may be traversing the bay. The batt should be split so that equal amounts of insulation are in back of and in front of those items. Ideally, nothing is viewable after insulation is installed except for the insulation product itself.
- If the batts have a vapor barrier attached to them then this facing should make contact with the sub-floor above it, touching the warm side of the assembly for best performance and to prevent moisture issues.
- Raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging, or deteriorating. Two approaches that accomplish this are:
    1. Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.
    2. Attaching wire or plastic mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.

3.4.2.2 *Standards for Loose-Fill Insulation*

- When choosing to use loose-fill insulation under floors it is mandatory that approved netting be used to hold the product securely in place.

3.4.2.3 *Standards for Spray Foam Insulation*

- All efforts must be made to adhere to local, state, and federal standards and codes as it relates to coverage and flame protection.

3.4.3 Verification

- QA review will include confirmation of work-scope and photo documentation of existing and upgraded insulation installations (insulation coverage and/or R-Values and 'installed location context' photos).
- FQC verification will include visual inspection and comparing installed levels to insulation charts showing R-values for the different types of insulation and may include invoice review.
- The location of insulation and how well it serves the occupants will be assessed.
    - Insulation installed in areas with no comfort or energy saving benefit does not qualify.
- Floor access hatches shall also be evaluated for their insulation effectiveness.

3.5 Duct Insulation

3.5.1 Minimum Requirements

- Duct insulation shall be R-8 or greater. Cover R-8 ducts (i.e., 'deep bury' in attic insulation) to the maximum insulation depth possible wherever and whenever possible.

3.5.2 Best Practices

- Cover R-8 ducts (i.e., 'deep bury' in attic insulation) to the maximum insulation depth possible wherever and whenever possible.

3.5.3 Verification

- QA review will include confirmation of work-scope and photo documentation of existing and upgraded duct systems (insulation coverage and/or R-Values, system anomalies [damage, disconnections, inefficiencies] and 'installed location context' photos).
- FQC verification will include visual inspection. Where it is not possible (i.e., where 'deep buried' in attic insulation), FQC verification may include temporarily moving attic insulation to facilitate visual inspection and/or verification of material installation documentation or review of invoice.

3.6 Duct Replacement

3.6.1 Minimum Requirements

- Installation of new ducts shall comply with Title 24, Chapter 6, Building Energy Efficiency Standards, including requirements for duct insulation and duct sealing, and third-party inspection by a certified HERS Rater. Duct leakage shall not exceed 5% of nominal or actual system air flow. Existing duct system must have 10% leakage or greater in order to be eligible for the duct replacement upgrade measure (to increase actual savings at the meter). Verification must be done using procedures defined in Appendix RA3 of California Energy Commission's Reference Appendices for the California Building Energy Efficiency Standards, Title 24, Part 6.[19]
- Home has not participated in duct test and seal or replacement program or has not done duct sealing (to less than 10 percent leakage) in past six years.
- Duct leakage shall not exceed 5% of nominal or actual system air flow. Existing duct system must have 10% leakage or greater in order to be eligible for the duct replacement upgrade measure (to increase actual savings at the meter).
- Home must be served by an existing central air conditioner, furnace, or heat pump; new systems installed when no prior equipment was present will not qualify since state building code already requires a duct test on these systems.
- Individual cooling systems must be between 1.5 and 5 tons capacity. Air conditioning systems with multiple compressors and economizers are not eligible. Up to two (2) systems at the same address are eligible in Advanced Home Upgrade.
- Ducts must be replaced and sealed in accordance with the requirements contained in the 2019 Residential Compliance Manual for the Building Energy Efficiency Standards, Section 4.4, "Air Distribution System Ducts, Plenums, Fans, and Filters" [20] and applicable BPI Standards.[21]

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[19] California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards, Title 24, Part 6*, www.energy.ca.gov/title24

[20] California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards, Title 24, Part 6*, www.energy.ca.gov/title24

[21] Building Performance Institute, *Current BPI Standards, www.bpi.org/standards/current-standards*

- In Advanced Home Upgrade, the work scope must include pre- and post-installation diagnostic duct leakage and system airflow testing if an existing duct system(s) was present. The results of these tests must be documented and used to verify the effectiveness of duct replacement installation(s), if performed. When quantifying duct leakage, an appropriate type of measurement system shall be used that includes a metered and calibrated duct pressurization device. Duct leakage shall be measured and documented any time that duct replacement is part of the work scope to verify the success of the installation.
- For Advanced Home Upgrade, duct replacement must comply with or exceed code requirements and utilize the same test measurement methods (nominal or actual, and total leakage or leakage to outside) for test-in and test-out.
- Sheet metal and flexible ductwork shall be sealed at all duct connections using duct mastic or similar product designed for sealing ducts. 'Duct tape' is not an allowable duct sealing material. UL 181, UL 181A or UL 181B certified tape may be used, typically on duct board systems components and at the connections to and/or on the air handler cabinet. Mastic is preferred (and lots of it)!
- CAS testing and blower door shall be performed whenever insulation, air sealing of shell or the ducts, or ventilation is installed to confirm safe conditions for the occupants.
- When heating ducts are located outside the building envelope or cooling ducts are located in attic spaces, they should be sealed underneath the duct wrap, at all accessible connections with duct mastic and insulated to a minimum R-8 as part of the work scope.

3.6.2 Best Practices

- Ducts should be designed in conformance with ACCA Manuals J, D, S & T.[22] Distribution systems should be sized according to the amount of air delivery required to each location and duct runs should be as short as possible. Main supply trunk velocities should be designed to deliver 700–900 feet per minute (FPM). Branch supply ducts should be designed for 500– 700 FPM. Minimize friction by designing systems with round duct systems and transfer to rectangular ducts minimally and with a transition piece in-between square to round. Duct System Replacement is required for projects also seeking to claim the Ultimate Comfort/HPHI measure on a project.
- To avoid polluted air migration through the distribution system, avoid installing return grills in bathrooms and kitchens. Make sure combustion zones are not affected by equipment operation.
- Avoid delivering conditioned air to very small rooms such as hall bathrooms or pantry. The room would most likely overheat/cool when the system is operating.
- Measure the temperature rise/drop of air moving across the HVAC system to ensure that it falls within manufacturer specifications.
- Pressure balance of the duct system. Any pressures created within any part of the building should not to exceed 3 Pascals of pressure (positive or negative) with reference to the outdoors, and temperature differences should not exceed 5 degrees Fahrenheit (positive or negative) from room-to-room when the HVAC system is running. Correct any zonal pressure differentials that create air leakage from the garage or other potentially contaminated zones into the house.
- Minimize conductive losses/gains through the distribution system:

[22] Air Conditioning Contractors of America, www.acca.org/standards/technical-manuals

    - Bury the ducts under the insulation layer.
    - Duct insulation shall be R-8 or greater.
    - Duct surface area should be minimized by shortening ducts whenever possible.
    - Run supply ducts to the closest corner of each room and minimizing the number of supply registers.
    - Plenums should be wrapped with fiberglass duct insulation or rigid insulation board.
- Strive for duct leakage near zero. The target for all new duct systems is to make them as tight as possible to both save energy and maintain performance. Brand new systems should be able to keep leakage below 50 cfm in the complete system with careful quality and craftsmanship.
- Seal take-off connections to register boots and boot connections to floors, walls, and ceilings.

Test the duct system (TDL and/or DLTO at CFM25) at initial installation completion; make air-sealing, supply air-flow, and pressure balance adjustments as needed; and then re-test the system.
Use the following checklist from BPI's Shell Standards as a guide for prioritizing duct sealing during installation of replacement duct system:

- Seal the largest leaks first. These include disconnected ducts, missing end-caps, and other catastrophic holes
- Seal the areas of highest pressure. These include all the connections near the air-handler cabinet and supply and return plenums, flexible canvas plenum connectors, and filter slot covers.
- Seal return leaks that may contribute to negative pressures in the combustion appliance zone.
- Seal all accessible connections between duct sections, at branches, and where take-offs connect to main trunk lines.

  Pressure imbalances may be corrected by:

    - Adding/enlarging a return air duct. Consider adding a return air duct to areas where occupants complain of discomfort, or erratic temperatures, or enlarging an existing return.
    - Undercutting doors to relieve pressures. A one-inch undercut of a door is often the easiest and most cost-effective solution.
    - Installing balancing grills through the wall.
    - Installing a jumper duct from the room to the main living area.

- The new duct system should be placed strategically to avoid over-heating or cooling. This might require moving a system from an attic to a crawl space area if it makes sense to do so, based on budget, performance enhancement, and delivery potential, and/or thoroughly air-sealing and deep-burying in insulation.

- Consider installing high-performing/commercial-style diffusers and grills for better, higher-velocity delivery and performance. These grills must be carefully selected and should be located at or near interior walls to keep duct runs shorter and straighter. They should have minimal interference within them (no or few dampers) and deliver air across the room to induce

convective currents. Never blow delivered air on the occupants, above a headboard of the master bed for example.

Bigger area at the return grill is a benefit to the system, but avoid increasing return air duct sizes too much, due to increased duct surface area being exposed to unconditioned air temperatures which increase heating and/or cooling loads.

3.6.3 Verification

- QA review will include confirmation of work-scope and photo documentation of existing and upgraded duct systems (insulation coverage and/or R-Values, system anomalies [damage, disconnections, inefficiencies] and 'installed location context' photos).
- FQC verification will include visual inspection, duct leakage testing at 25 Pascals (via the testing method contractor used for reporting – TDL or DLTO), and/or review of invoice.
- CAS testing will be performed on gas appliances.
- The following procedures for testing total duct leakage (TDL) will be utilized:
    - The duct zone should be relieved of any potential pressures by opening it up to the outdoors. This can be done by opening a window or door. The point is to create as close to zero pressure around the duct, so that leaks can be measured at a specific pressure of 25 Pascals (i.e., CFM25).
    - All ducts are to be closed and sealed at the register with duct mask, tape, or plastic wrap. It is important to make sure that ALL supply and return registers are sealed. Otherwise there is no accuracy to the test. Seal any register grills that may be in the plenums of the appliance. Make a final pass around the building prior to conducting the test, and look for any registers that may have been missed.
    - Configure the building and install diagnostic equipment for duct leakage testing. For testing to be valid, you must set up a repeatable testing scenario.
    - Disable all vented combustion appliances and air conditioners.
    - Establish a manometer to measure the fan pressure of the duct blaster with respect to duct zone.
- For testing duct leakage to outside (DLTO), procedures will follow CEC protocols in the Building Energy Efficiency Standards Reference Appendices RA3.1.4.3.4.
- The location of duct sealing efforts will be evaluated to determine effectiveness and ensure that all efforts had been made to eliminate air leakage out of the distribution system.
- FQC verifiers will also be checking specifically for zero percent leakage on the return-side of the system if it is sharing space with other combustion appliances.

3.7 Heating & Cooling (HVAC) Equipment Replacement

3.7.1 Minimum Requirements

- All heating and cooling equipment replacement must meet Title 24, Chapter 6, Building Energy Efficiency Standards, including requirements for ducts sealing, setback thermostat, refrigerant

charge verification, minimum cooling coil airflow, and requirements to conduct a complete system third-party inspection by a certified HERS Rater.[23]

- Equipment upgrades must be for the same type of utility supplied to the existing/original unit (i.e., existing gas central furnace upgraded to higher-efficiency gas central furnace or existing electric heat-pump upgraded to higher-efficiency electric heat-pump – no fuel switching can be incentivized in the program – gas central furnace/AC units can be upgraded to an electric heat-pump, as long as the upgraded AC is higher-efficiency and meets the measure requirement for cooling efficiency, but will not be able to claim the heating upgrade measure under this scenario, due to the switch in fuel sources for the heating side of the equipment).
- All replacement equipment and ducts shall be properly sized according to ACCA Manuals J, D, S, and T at a minimum, with specific room-by-room load calculations, no "rule-of-thumb" sizing. Air conditioning evaporator coils and condensing units must be properly matched according to ACCA Manual S so that they can deliver the rated efficiency.[24]
- Central natural gas furnaces must have an Annual Fuel Utilization Efficiency (AFUE) rating of 92 percent or greater.
- At the conclusion of projects for buildings with 2-4 units, all heating and domestic hot water appliances for all units must be either (1) power vented or closed combustion, (2) moved outside the building shell (including garages and attics), or (3) sealed off from the living space such that there is adequate combustion air and combustion gases are appropriately exhausted. This is true whether or not each unit participates in the Advanced Home Upgrade Program.
- Air Conditioning and Heat-Pump systems must meet or exceed the following minimum performance standards in Table 2 (below):

Table 2. Advanced Home Upgrade HVAC (minimum) Performance Standards

	SEER	EER	HSPF
Split central AC	15	12.5	
Packaged central AC	15	12.0	
Split Heat-Pump/AC	15	12.5	9.0

[23] California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards, Title 24, Part 6*, www.energy.ca.gov/title24

[24] Air Conditioning Contractors of America, *Manual J Residential Load Calculation*, *Manual D Residential Duct Systems, Manual S Residential Equipment Selection* and *Manual T Air Distribution Basics for Residential Buildings,* www.acca.org/industry/ansi-standards

3.7.2 Best Practices

- When installing a new HVAC system, always try to locate it in an area not subject to extreme temperatures (attics), and look for locations that are central that will require shorter, straighter duct runs.
- If the home is too small for conventional gas-fired furnace output, consider a combined hydronic heating system which utilizes a hot-water heat exchange with the water heater.
- Air-Source Heat Pumps might be a wise choice when replacing electric systems and/or the home is adding Solar PV.
- Insertion of high resistance filters could add extraneous static pressure to the system unless it has been designed to accommodate such filters. For best performance, filter pressure drop should not exceed 0.05 inches of water column. Systems designed to utilize filters rated MERV 6 or more should be designed to accommodate the additional static pressure these more restrictive filters present. It is also good practice to create filter slots near the air handler that will accommodate the increased filter thickness.

3.7.3 Verification

- QA review will include confirmation of work-scope and photo documentation of existing and upgraded equipment (nameplates and 'installed location context' photos), as well as AHRI certificate and inspector-signed HVAC permit 'final'.
- FQC verification will include visual inspection of equipment and/or review of invoice.
- System airflow measurement will be performed if used for duct leakage calculation.
- CAS testing will be performed on gas appliances.

3.8 High Performance HVAC Installation

High Performance HVAC Installation (HPHI) is commissioning of central, ducted residential HVAC systems (i.e., measurement of performance to verify higher efficiency program 'bonus' measure requirements). HPHI is designed to yield increased energy savings benefits and enhanced occupant comfort relative to traditional HVAC installations. The prescribed approach is to first maximize shell improvements (air sealing and insulation), then design a more efficient HVAC and duct system, and finish by measuring and achieving system performance targets. Additionally, high-efficiency continuous mechanical ventilation shall be provided when required (per Title 24 and ASHRAE 62.2) or as needed.

3.8.1 Minimum Requirements

- ACCA Manual J, D, S, and T design is required and must be documented for all HPHI project HVAC systems.
- All HPHI Projects shall measure, record (on HPHI installer [Excel] worksheet) central, ducted HVAC system installation and performance data, to meet or exceed the specified requirements (1-7) below:

ITEM	MEASURE	PERFORMANCE & MEASUREMENT TARGETS
1	HEATING & COOLING EFFICIENCIES	92% AFUE FURNACE; 9.0 HSPF HEAT-PUMP; 15 SEER/12.5 EER
2	MAXIMUM CAPACITY	1 TON / 800 SF; 18 BTUH/SF HEATING
3	SYSTEM AIRFLOW	> 450 CFM/TON, < 0.25 WATTS/CFM
4	DUCT INSTALLATION AND AIRTIGHTNESS	3% TOTAL LEAKAGE; RUN SHORT, LOW, FULLY EXTENDED
5	NET DELIVERED EFFICIENCY (BTUs/WATT)	> 85% OF MANUFACTURER PERFORMANCE TABLES
6	ROOM AIR DELIVERY	3 DEGREE AND 5 PASCAL MAX DEVIATION*
7	VENTILATION	ASHRAE 62.2-2010 MINIMUM VENTILATION @> 5 CFM/WATT

* ROOM AIRFLOWS MUST INITIALLY BE BALANCED TO WITHIN 10% OF DESIGN VALUES. IF ITEM 6 TESTING DEMONSTRATES OTHERWISE, VALUES CAN DEVIATE FROM 10% AS NECESSARY TO MEET 3 DEGREE ROOM AMBIENT VARIATION TARGET.

3.8.2 Best Practices

- Measure your work before, during, and after installation; then, adjust as needed.
- Select HPHI candidate homes with practical layouts that facilitate successful achievement of performance requirements.
- Select customers that are more interested in system performance, reducing energy bills, and increasing comfort, rather than having the project completed as quickly as possible; then, manage expectations accordingly during the project (don't promise results in advance unless you know you can deliver, outline project timeline).
- Document everything with notes, photos, contract/work-scope, ACCA calcs/layout, and data recorded in the HPHI workbook (the Excel-based HPHI project documentation and calculation spreadsheet).
- When in doubt, contact you mentor/trainer and Build It Green.

3.8.3 Verification

- FQC verification will include visual inspection of equipment, re-measurement of HPHI Workbook requirements, and/or review of project documentation (work-scope/invoice, ACCA load and duct calcs, photos, etc). See program website for additional information and measure documentation (www.homeupgrade.org/grow-business/highperformance).
- CAS testing will be performed on gas appliances.

3.9 Storage Water Heaters

3.9.1 Minimum Requirements

- Replacement of domestic hot water (DHW) systems shall comply with Title 24, Chapter 6, Building Energy Efficiency Standards[25] (including domestic water Pipe Insulation) and shall meet or exceed ENERGY STAR standards when applicable.
- Minimum equipment efficiency ratings are as follows:
    - 0.70 EF/UEF or better for Non-Condensing Gas Storage Water Heater
    - 0.90 EF/UEF or better for Condensing Gas Storage Water Heater
    - 3.24 EF / 3.09 UEF or better for Electric (Heat-Pump) Storage Water Heater
- Equipment upgrades must be for the same type of utility supplied to the existing/original unit (i.e., existing gas DHW upgraded to higher-efficiency gas DHW or existing electric DHW upgraded to higher-efficiency electric DHW – no fuel switching can be incentivized in the program).
- Install per manufacturer's specifications.
- At the conclusion of projects for buildings with 2-4 units, all heating and domestic hot water appliances for all units must be either (1) power vented or closed combustion, (2) moved outside the building shell (including garages and attics), or (3) sealed off from the living space such that there is adequate combustion air and combustion gases are appropriately exhausted. This is true whether or not each unit participates in the Advanced Home Upgrade program.

3.9.2 Best Practices

- When replacing the water heater, replace with maximum efficiency unit with sealed combustion, direct vent design in order to eliminate the threat of flue gas spillage or flue back-drafting.
- Select units in anticipation of future solar pre-heat if climate and location allow. Prep for solar water pre-heating.
- Select units that take advantage of lowest fuel costs and the wishes of client. As an example, if there is both electricity and natural gas available at the site, and the customer has a wish to be carbon neutral, they may prefer to have an all-electric home that produces zero harmful carbon emissions. In this case, an electric water heater could be used. It could be augmented by adding solar pre-heat and only heating with electricity at night to take advantage of lower rates.
- Seek the highest feasible Energy Factor within budget.
- Insulate all accessible pipes per current standards (or better), as specified by Title 24, Part 6.
- Install thermostatic control shower valves and/or thermostatic control tub-spout diverters whenever possible.
- Install low-flow shower valves (e.g., WaterSense labeled products) whenever possible.
- Install on-demand, point-of-use recirculation pumps where feasible.
- Install structured plumbing systems to minimize pipe length and increase delivery performance.

[25] California Energy Commission *Building Energy Efficiency Standards, Title 24, Part 6*, www.energy.ca.gov/title24

3.9.3 Verification

- QA review will include confirmation of work-scope and photo documentation of existing and upgraded equipment (nameplates and 'installed location context' photos).
- FQC verification will include visual inspection of equipment and/or review of invoice.
- CAS testing will be performed on gas appliances.

3.10 Variable Speed Pool Pump

3.10.1 Minimum Requirements

- Certified Aquatic Equipment Installer (CAEI) must evaluate the existing system, specify, and install code-compliant (per CEC's Title 20 *Appliance Efficiency Regulations* and Title 24, Part 6) variable speed pool pump replacing existing single or two-speed pump (primary in-ground pool system only; no Jacuzzis or above-ground pools).
- This measure is not eligible for completely new pool system installations (i.e., pool enclosure, pool pipe system and/or pool filtration system – replacement or cleaning of filter media [for the same type of filter media] on existing pool filtration systems is okay).
- Submit photos of existing pool pump and upgraded pool pump (nameplate and within context of installed area for both) with each project that the pool pump upgrade measure is claimed on.

3.10.2 Best Practices

- In order to maximize pump efficiency and filtration-system effectiveness, variable speed pool pumps should be installed to target as close to 1.5 turns per day (i.e., the total volume of pool system water shall cycle through the filtration system 1.5 times per day), utilizing existing pipe diameter and filtration system.

3.10.3 Verification

- QA Review will include confirmation of work-scope and photo documentation (existing and upgraded equipment), including CAEI assessment and installation.
- FQC verification will include visual inspection of equipment and/or review of invoice.

3.11 Smart Thermostat

3.11.1 Minimum Requirements

- Thermostat upgrade must replace existing programmable (non-'Smart') or non-programmable thermostat with an EnergyStar certified, WiFi-enabled Smart Thermostat.
- WiFi-enabled Smart Thermostat shall demonstrate Wi-Fi connection at installation, confirmed via test login.

- Submit photos of existing/original thermostat, as well as photos of new Smart Thermostat at installation location and confirmed WiFi login with each project that Smart Thermostat upgrade measure is claimed on.

3.11.2 Best Practices

- Follow manufacturer's installation instructions for location of Smart Thermostat, taking into account the number of HVAC zones/systems in each dwelling unit.

3.11.3 Verification

- QA Review will include confirmation of work-scope and photo documentation, including confirmed WiFi login photo or screenshot.
- FQC verification will include visual inspection of equipment and/or review of invoice.

3.12 LED Recessed Light Fixtures

3.12.1 Minimum Requirements

- Lighting upgrade must replace existing medium-base screw-in incandescent or CFL recessed interior fixture (i.e., ceiling can light) with pin-base recessed interior high-efficacy LED retrofit fixture (Title 24 - JA8 Compliant, including IC-AT rated fixture enclosure in the attic if replacing the entire fixture housing).
- Submit photos (minimum of two; nameplate/screw-in-base without lamp/bulb and within context of installed area, with lamp/bulb installed) of typical instance of each type of existing recessed interior light fixture(s) to be upgraded and photos (minimum of two; nameplate/pin-base without lamp/bulb and within context of installed area, with lamp/bulb installed) of replacement pin-base recessed interior high-efficacy LED retrofit fixture that the upgrade measure is claimed on.
- Comply with insulation clearance and/or encapsulation requirements for heat producing devices in Section 3.2.1 of this document and per Title 24 if insulating over and/or around recessed lighting fixture housings in the attic.

3.12.2 Best Practices

- In addition to replacing existing recessed lighting with Title 24 - JA8 Compliant IC-AT rated recessed LED fixtures and air-sealing where they penetrate the attic place, consider removing as many recessed light fixtures as possible (in favor of no replacement lighting or flush-mounted lighting, in order to reduce potential pathways for building leakage).

3.12.3 Verification

- QA Review will include confirmation of work-scope and photo documentation of predominant type(s) of existing light fixtures and lamps, as well as the upgraded fixture and lamp type.

- FQC verification will include visual inspection of lighting and/or review of invoice.

4 Program Information and Questions

For additional information regarding Advanced Home Upgrade measures installation, please visit the Program website at www.homeupgrade.org or contact Build It Green at 510-285-6222.

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