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| **Docket Number:** | 16-BSTD-07 |
| **Project Title:** | Local Ordinance Applications - 2016 Standards |
| **TN #:** | 212812-3 |
| **Document Title:** | San Francisco 2016 Local Ordinance Staff Report |
| **Description:** | N/A |
| **Filer:** | Ingrid Neumann |
| **Organization:** | City and County of San Francisco |
| **Submitter Role:** | Public Agency |
| **Submission Date:** | 8/16/2016 4:44:25 PM |
| **Docketed Date:** | 8/16/2016 |

# San Francisco Better Roofs Policy – Phase 1

# Department of Environment Staff Report

California Title 24 (2013) requires that a minimum of 15% of roof area in most new buildings (or 250 square feet of roof area in new single family homes) must be "Solar Ready" – reserved for future installation of solar energy systems. Supervisor Weiner has sponsored a legislative proposal that would require that new buildings in San Francisco activate this solar ready area by installing solar electricity generation and/or solar thermal. The Department of Environment provides this report for both context and to inform discussion of cost-effectiveness of the proposed ordinance.

Considerable research by the Planning Department, Environment, SFPUC, and the 2013 "Greener and Better Roofs Roadmap" report from SPUR's Green Roof Task Force recognizes that – in addition to being a prime location for renewable energy resources – roofs can host 'green' or 'living roofs' with many additional benefits such as reducing stormwater entering the sewer, enhancing biodiversity and habitat, sequestering carbon, capturing pollution, and connecting citizens with nature. Therefore, staff suggest that this policy be an initial phase of a larger effort to activate roofs:

- Phase 1 – Require installation of solar energy systems in the 'Solar Ready' zone in new buildings (This ordinance)
- Phase 2 – Add the option of living roofs, requiring the solar ready zone to be used for any combination of solar photovoltaics, solar thermal, and/or living roof in new buildings. (Under research by Planning and Environment)
- Phase 3 – Maximize the public benefit of roofs, by activating the entire roof with any combination of solar energy systems, living roof, open space such as roof decks, after accommodating equipment code-requirements for fire access, skylights, and all similar considerations.

## 1. Policy Snapshot

Applicability:
New residential, commercial and municipal buildings of 10 occupied floors or less. Excludes data center and laboratory buildings.

Minimum roof area allocated to Better Roof uses:
Area equal to the Solar Ready Area specified in the California Energy Standards, which is 15 percent of total roof area for multifamily and non-residential buildings, and 250 square feet for single family residential.

Allowed Better Roof uses:
Any combination of solar photovoltaic systems and solar thermal systems.

City department roles:
The Department of Building and Inspection will review project plans and inspect installations to verify compliance with all applicable codes.

## 2. Background

The Department of Environment prepared the proposed Better Roof ordinance at the request of Supervisor Scott Weiner, and the Commission on the Environment. The ordinance builds on existing California's Title 24 Energy Standards which, since July 1, 2014, have required new residential and hotel buildings of 10 floors or less, and new non-residential buildings of 3 floors or less, to be designed with a minimum area of roof space designated as "Solar Ready" if solar is not installed at time of construction.[1] The area designated as the Solar Ready zone must be free of obstructions and shading that could interfere with installation or performance of a future solar energy system. Shading by existing structures and objects reduces these requirements accordingly.

## 3. Requirements

The Better Roof ordinance first requires the calculation of the Solar Ready area required under California Title 24 Part 6 Building Energy Standards. This area is equal to 15 percent of total roof area for residential buildings of 10 floors or less and 250 square feet for single family homes. The ordinance extends applicability of the Solar Ready requirement to all non-residential buildings of 10 floors or less, requiring a Solar Ready area equal to 15 percent of total roof area. Under this ordinance, the Solar Ready zone must be put to productive use by installing solar energy systems at time of construction, which is reasonable because solar photovoltaics and solar thermal are generally cost-effective (see Cost-Effectiveness section of this report). Eligible systems include solar photovoltaic systems, solar water heating systems, or any combination. Where a building is shaded by existing structures and objects, the Title 24 solar ready requirement and San Francisco's solar installation requirement are reduced accordingly.

The ordinance includes minimum performance requirements for solar photovoltaics and solar hot water systems to ensure that solar collectors are laid out for effective energy production in the Better Roof area. Photovoltaic systems must be designed with at least 10 Watts of rated DC nameplate capacity per square foot of Better Roof area dedicated to those systems. Solar water heating systems must be designed to generate annually 100 kBtu of thermal energy per square foot of Better Roof area dedicated to those systems.

The Better Roof ordinance applies to all newly constructed single-family homes, and newly constructed residential and non-residential buildings with 10 occupied floors or less. The ordinance refers to the number of occupied floors rather than building height for purposes of consistency with Title 24 Solar Ready requirement, and to simplify Phases 2 and 3 – where the California Building Code and San Francisco Planning Code each define different ways of calculating the height of a building. These are the same building types that are currently subject to the statewide Solar Ready requirement – with three exceptions:

[1] California Code of Regulations, Title 24 (2013), Part 6, Section 110.10.

- Title 24 Solar Ready requirements apply only to single family residential in developments of at least 10 new homes, whereas the Better Roof ordinance applies to all single family homes.
- Title 24 Solar Ready requirements apply to new non-residential buildings of 3 floors or less, and to new multifamily and hotels of 10 floors or less. The Better Roof ordinance applies to new non-residential and all new residential buildings that are not high-rise as defined by California Building Code Section 202.
- Title 24 Solar Ready requirements apply to all new non-residential occupancy types, while the Better Roof ordinance does not apply to buildings that are primarily laboratory or data center occupancy.

## 4. Policy objectives

Since 2010, San Francisco's Green Building Code has had a modest renewable energy requirement for new commercial buildings larger than 25,000 square feet, which can be met one of three ways: install on-site renewable energy systems sufficient to meet 1% of total annual energy cost, purchase Renewable Energy Certificates (RECs) for power generated off-site, or improve efficiency 10% beyond Title 24 (in addition to meeting any other applicable energy efficiency requirements.) This requirement is often met with purchase of RECs. Since 2014, California Energy Standards have required solar-ready building design, but not installation of solar. Requiring on-site solar generation at time of construction advances these existing policies to provide the near-term impact necessary to help San Francisco achieve its greenhouse gas reduction targets and goal of 100 percent renewable energy. On-site solar generation also provides energy cost savings. Today, solar photovoltaic systems are often installed voluntarily by the building owner for long term cost savings, to meet sustainability goals, and/or to achieve a green building certification. Solar water heating systems are often installed on new affordable multifamily residential properties with central domestic hot water heating systems in order to comply with energy efficiency requirements of Title 24, San Francisco Green Building Code, and financing providers.

Subsequent phases of Better Roofs will give the building designer the flexibility to choose the best combination of solar photovoltaic, solar water heating and living roof systems to maximize benefit based on location and building program.

## 5. Precedent

Since 2013, three California cities, Lancaster, Sebastopol, and Santa Monica, have adopted requirements to install a minimum amount of solar photovoltaics on new buildings. These cities are each considerably less dense than San Francisco. Under this Better Roof ordinance, San Francisco would be the first major US city to require solar on new buildings.

Similarly, major U.S. cities including Chicago, Washington DC, and Portland require living roofs on certain new buildings. Subsequent phases affording solar and living roof options

entail both a more flexible approach and extension to a wider array of building occupancies and sizes than any other community to date.

## 6. Solar Cost-effectiveness

Department of Environment has completed cost effectiveness analysis of solar photovoltaics. ARUP Engineers performed cost effectiveness analysis of living roofs on behalf of the Planning Department and Environment. This section summarizes the analyses and results.

### 6.1. Process

To determine the cost-effectiveness of the proposed ordinance, two studies evaluated the costs and benefits of two paths to comply with the ordinance: 1) entirely via photovoltaics,[2] and 2) exclusively via a living roof.[3] Solar water heating was not separately evaluated because as a practical matter such systems are limited to buildings with high hot water consumption, and are likely to be installed for their benefits and to fulfill multiple compliance obligations. For example, in multifamily housing with central water heating, solar water heating is often installed to meet San Francisco Green Building Code energy efficiency requirements. Such a system would also contribute to compliance with the Better Roof ordinance.

The financial analyses considered costs and benefits over a 25-year period. Results are shown in net present value, after discounting future cash flows.

### 6.2. Analysis

To understand the implications of solar energy as a compliance option, the cost-effectiveness of meeting the proposed Better Roof requirement entirely with photovoltaics was studied. A variety of building types and uses were modeled, from single-family homes to high-rise office.

The analysis assumed that the building owner paid all costs and derived all benefits from the photovoltaic system. The federal solar Investment Tax Credit (ITC) was assumed to be the only financial incentive available. The ITC provides a one-time credit of 30 percent of photovoltaic system cost against the income taxes owed by the owner, and was recently extended by Congress to apply to systems installed before the end 2019. In its current form, the credit drops to 26% in 2020, 22% in 2021, and drops 'permanently' to 10% for commercial and 0% for residential for systems installed in 2022 or thereafter.

The solar financial analysis considered costs and benefits over a 25-year period. Costs included the one-time costs to design, purchase and install the photovoltaic system, as well as the ongoing costs of financing, operation, maintenance and insurance. The photovoltaic system was assumed to be financed as part of the overall building

[2] Ari Halberstadt, *Report on Cost-Effectiveness and Other Analyses for Proposed Solar Ordinance*, 2014.
[3] ARUP, *San Francisco Living Roof Cost-Benefit Study Summary Report*, 2015.

construction project, so that one-time costs were paid over time as loan payments. Benefits included the ongoing value of solar electricity generated (it was assumed that the solar electricity directly reduced the electricity purchased from the utility by the owner), and the net reduction to the owner's federal and state taxes owed.

Conservative values were used for all inputs to the model, based on San Francisco data when available and on national data when necessary. A sensitivity analysis was then performed to evaluate the effect of different input values on the cost-effectiveness.

## 6.3. Results

The analysis shows that installing photovoltaics to comply with the proposed Better Roof ordinance is cost-effective for all building types with today's input values, summarized in Table 1. When the benefits over the life of the system are discounted to account for time and divided by the costs, a ratio of 1.0 indicates the action is cost-effective. Cost-effectiveness is expected to improve over time as the industry has a long term trend of decreasing costs and increasing energy production per unit; from 2008 to 2014, the installed cost of photovoltaics declined by 55%.[4]

The most common method of financing photovoltaic systems today is through third-party ownership. Though third-party ownership was not analyzed in the study, it is demonstrably cost-effective because the third-party is a for-profit business. Under the third-party ownership model a solar leasing company will purchase, install, operate and maintain the photovoltaic system for 20 or more years. The solar electricity is used in the building for the benefit of the building owner or tenants. The building owner incurs no up-front costs, and instead makes recurring payments to the solar leasing company in exchange for use of the solar electricity. The owner's payments to the solar company are less than the avoided electricity payments to the utility, making this option clearly cost-effective for owner-occupied buildings.

The avoided emissions resulting from the clean electricity generated by photovoltaic systems is a benefit to the broader community that was not factored into the cost-effectiveness calculation. The aggregate impact of installing photovoltaics to minimally comply with the proposed Better Roof ordinance on all 200 major new construction projects in San Francisco Planning Department's project pipeline as of third quarter 2014 would be to avoid over 26,000 metric tons of carbon dioxide emissions per year.

*Table 1. Benefit-to-cost ratios of photovoltaic systems on representative building types. Values greater than or equal to 1.0 indicate cost-effectiveness.*

| Building type | Benefit-to-cost ratio |
|---|---|

[4] LBNL (2015) *Tracking the Sun VIII, Installed Price of Residential and Non-Residential Photovoltaic Systems.* https://emp.lbl.gov/sites/all/files/lbnl-188238_1.pdf

| | |
|---|---|
| Single-family residential | 1.95 |
| Multifamily residential | 1.69 |
| Warehouse | 1.20 |
| Small restaurant | 1.21 |
| Small office | 1.10 |
| Large office | 1.17 |
| Medium retail | 1.09 |
| Large retail | 1.09 |

## 6.4. Living roof analysis

ARUP engineers analyzed the cost-effectiveness of a possible future compliance option: meeting the proposed Better Roof requirement entirely with a living roof that uses 6 inches of lightweight media with native and adapted plants. The analysis included two building types of similar size that are good candidates for living roof: medium commercial and small multifamily. The costs and benefits of the living roof were compared to the costs and benefits of a baseline membrane roof with cool white coating that is a requirement for prescriptive compliance with California Title 24 Part 6 (2013) for most building types in the CEC's "Climate Zone 3", which includes all of San Francisco. In both the living roof and baseline case, the building was required to comply with San Francisco's Stormwater Management Ordinance.

Costs and benefits of the living roof are over the 25-year period are presented as those net of the costs and benefits of the baseline roof. In addition to initial installation costs, recurring costs of maintenance, irrigation, and reroofing were evaluated. Benefits included the avoided one-time cost of installing stormwater management equipment that would be required if not for the living roof, as well as ongoing benefits of energy savings, carbon abatement, heat island mitigation, air quality improvement, noise abatement, habitat addition, productivity increase based on biophilic effect, job creation and increased real estate value. The methodology applied by ARUP was based in large part on prior work for the US General Services Administration.[5]

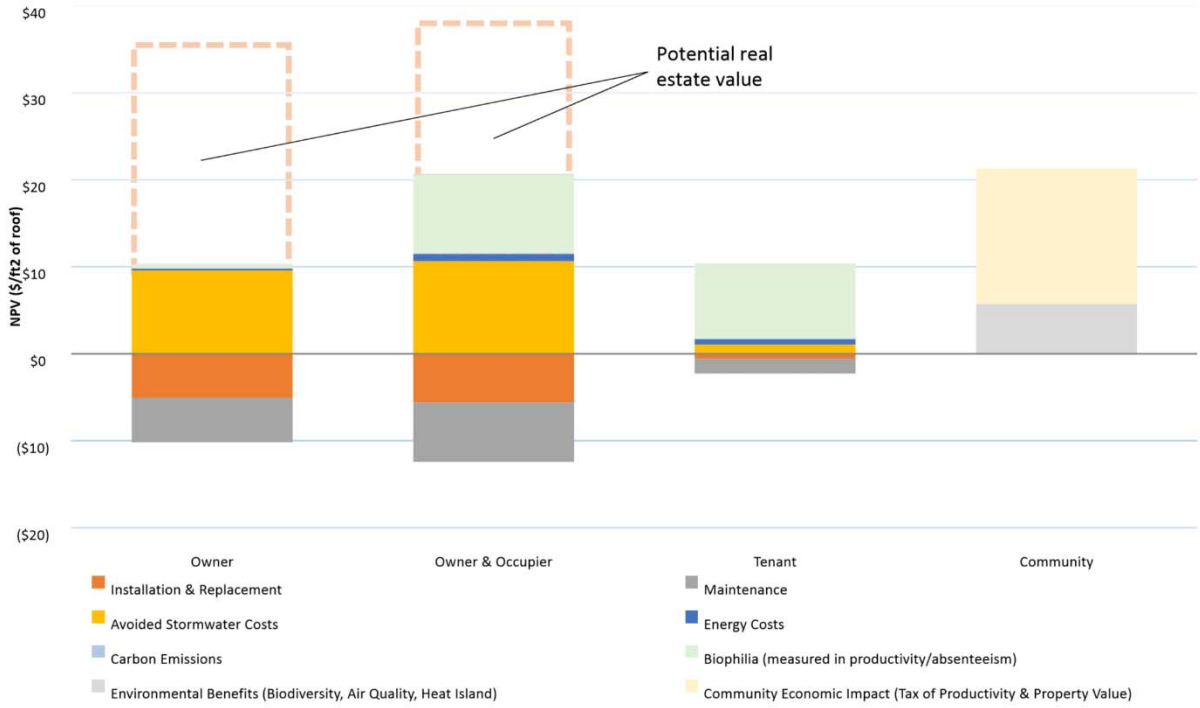
[5] ARUP, Benefits and Challenges of Green Roofs on Public and Commercial Buildings, 2011.

Living roof data from San Francisco were used in the financial analysis, and supplemented with national data when necessary. Local data were afforded greater weight in all calculations.

## 6.5. Living roof results

The analysis found that a living roof provides net financial benefit to the building owner, while providing significant additional benefit to tenants, and the broader community. The largest cost of a living roof – the one-time installation cost – is largely offset by the avoided one-time stormwater management equipment costs that would be incurred with the baseline roof. Both of these one-time costs and benefits accrue directly to the building owner.

*Figure 1. Costs and benefits accrued to project stakeholders in dollars per square foot of living roof, net present value over 25-year period.*




The largest potential benefit is added real estate value, which also accrues to the building owner. Added real estate value may be realized in the form of faster tenant recruitment and longer retention, risk reduction, higher rent, and increased net operating income (NOI) due to operating expense savings. However, even in the absence of these benefits, which are well documented, the living roof was found to be cost-neutral.

Figure 1 shows the net costs and net benefits of the living roof compared to the baseline roof for the range of the stakeholders in development: owner, owner & occupier, tenant, and the community. Excluding benefits to real estate value, benefit to the owner were found to offset the costs. The net impact is greater for an owner-occupied building in which the owner benefits from energy savings and biophilic effects. Two examples of these biophilic effects that enhance real estate economics include improved ability of businesses to attract and retain talent, as well as ample evidence of improved productivity for employees exposed to nature at the workplace. This analysis does not rely on such effects, but their value is considerable and ARUP's literature review provides ample documentation that such effects have been realized in many similar contexts.

## 6.6. Initial construction cost

Analyses by ARUP Engineers and consultant to Department of Environment Ari Halberstadt demonstrate that photovoltaics and living roofs are both cost effective in the context of current market prices and conservatively calculated long term benefits. The initial cost of each technology depends on location and financing. It is possible to install either technology in compliance with a Better Roofs ordinance with no increase in construction cost compared to compliance with existing requirements:

- In dense urban areas where due to real estate economics and land use regulations, 'zero lot line' structures (i.e. buildings that occupy the entire parcel) are favored, a well-designed living roof may be the primary BMP for compliance with SFPUC Stormwater Requirements. A living roof may in certain uses and locations be additionally designed to provide accessible open space to occupants. In either of these circumstances, compliance with existing regulations, zoning, and area plans is already a feature of project cost.
- More than 75% of solar photovoltaic systems installed in California utilize a Power Purchase Agreement (PPA) contract[6] where a third party owns the system and sells power at a predetermined price (generally below market rate utility tariffs). In PPAs for roof-mounted solar, the customer is generally the building owner or occupants. Under a PPA, capital costs of solar power are entirely borne by the third party.

  Similarly, the legislation enabling San Francisco's Property Assessed Clean Energy (PACE) financing program, GreenFinanceSF, allows for financing eligible systems in new construction. Under this approach, avoided energy costs can provide the cash flow for financing eligible systems, which include solar photovoltaics, solar hot water, and living roofs.

- It is common for developers of new affordable multifamily housing to install solar hot water heating – primarily to comply with lender financing requirements that

[6] US Department of Energy EERE (2012) http://apps3.eere.energy.gov/greenpower/onsite/solar_financing.shtml

are intended to minimize utility cost for residents, but this approach also contributes to compliance with current energy codes.

For these reasons, analyses of costs *and benefits* over the life of the building, such as those discussed in the prior section, provide a more reasonable picture of the impacts of this ordinance than looking at first costs in isolation. We provide the following review of first costs in order to make a recommendation about the ratio between living roof and solar as uses of roof area.

*Table 2. Photovoltaic cost per unit area and power density*

| System size | PV Installed Cost[7] (dollars per watt) | Average Cost (dollars per square foot of solar collector) |
|---|---|---|
| <10 kW | $ 5.32 | $ 106.09 |
| >=10 kW | $ 4.32 | $ 86.15 |

*Table 3. Photovoltaic power density (wattage/sq ft)*

| Panel wattage (DC rated watts) | Panel size (square feet) | PV DC rated watts per square foot | Roof square feet per kilowatt PV |
|---|---|---|---|
| 345 | 17.3 | 19.9 | 50.1 |

*Table 4. Ratio of first cost: solar photovoltaics vs. living roof*

| Building Type | Roof size | Minimum Better Roof area (ft2) | PV system size (DC rated kW) | System cost | Cost per square foot of PV | Cost per square foot of Living Roof | Cost Ratio (PV: Living roof) |
|---|---|---|---|---|---|---|---|
| 2-Unit Residential | 2000 | 250 | 4.99 | $26,523 | $106 | | 3.4 |
| Residential Mid-rise | 10000 | 1500 | 29.9 | $129,225 | $86 | $32 | 2.7 |
| Commercial | 10000 | 1500 | 29.9 | $129,225 | $86 | | 2.7 |

*Table 5. Example Estimated Cost Per Gross Square Foot of Building Floor Area*

[7] CA Solar Statistics (2015) https://www.californiasolarstatistics.ca.gov/ Data collected February 1, 2015.

| Building Type | Number of Floors | Building Floor Area | PV initial cost per square foot gross floor area | Living Roof initial cost per square foot gross floor area |
|---|---|---|---|---|
| 2-Unit Residential | 2 | 4000 | $6.63 | $3.94 |
| Residential Mid-rise | 8 | 80000 | $ 1.62 | $1.18 |
| Commercial | 8 | 80000 | $ 1.62 | $1.18 |

## 7. Conclusion

Compliance with the proposed Better Roof ordinance via either a living roof or solar photovoltaics is cost-effective. The analyses showed that for both living roofs and photovoltaics, when all costs and benefits are combined and accrue over a 25-year period, the costs to the building owner are more than offset by the benefits. Solar water heating remains a third compliance option for the proposed Better Roof ordinance in cases where it is cost-effective, as is often the case today in affordable multifamily housing.

Beyond the traditional financial equation for the building owner, these productive uses of the roof also offer significant value to the broader San Francisco community such as improved views from neighboring buildings, improved urban air quality and carbon emissions reductions.

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