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Solar PV Design and Benefits for New Construction

Presented by:

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Solar PV Design and Benefits for New Construction

Presentation Outline

- Why is solar important to architects, owners and developers?
- California Energy Code (CEC) impacts for solar PV
- Solar financial impacts for new construction
- Meeting minimum CEC requirements
- Making buildings solar ready
- Roof is the real estate for solar
- Roof top designs to optimize solar integration
- Case studies of roof top conflict resolution for solar systems
- Planning and design for solar
  - Structural modifications for racking
  - Solar meter, consolidating loads, utility billing
  - Electrical rough-ins and Title 24
  - Shade Studies
- Racking and mounting types (UL 2703 impacts)
- Roofing details for racking

Key Takeaways

- 2013 code changes affecting solar
- Making projects solar ready
- Resolving design challenges and conflicts for solar systems
- Optimizing solar financial benefits through proper design
- Solar engineering best practices
- Solar Powered Apartments
- Financial benefits of solar

- Don’t forget commercial solar thermal as being very viable

Solar PV – Green Benefits and Carbon Reduction

- **For every 100kW of solar PV in California, over it's lifetime the system will offset…**

1,598,716 Pounds of Carbon Dioxide, the most abundant Greenhouse Gas

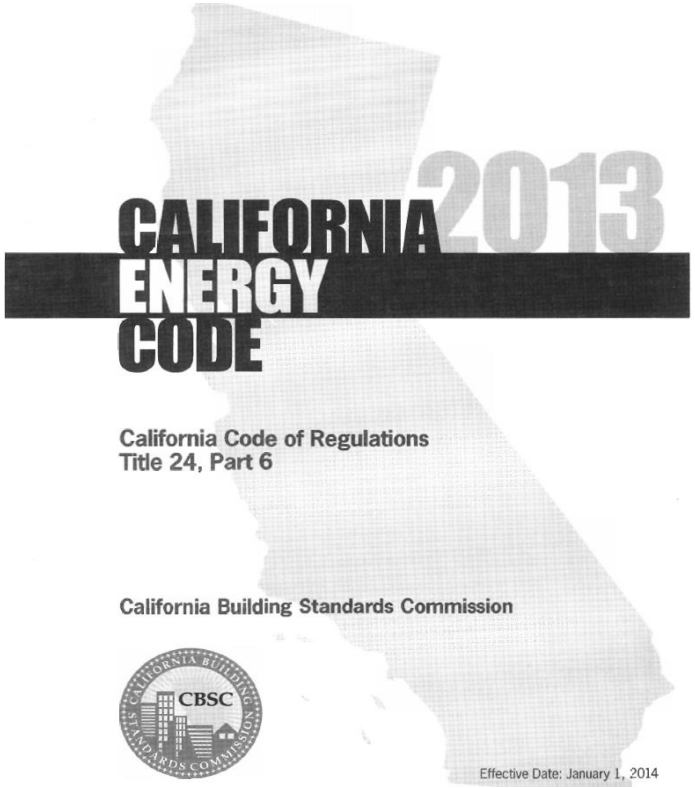
89 Pounds of Methane (CH4), one of the most potent Greenhouse Gases

575 Pounds of NOx (Nitrogen Oxides), a leading cause of Smog

405 Pounds of SO2 (Sulfur Dioxide), a leading cause of Acid Rain

Changes In California Energy Code

- Most new buildings MUST be solar ready to meet CEC
- Commercial & Multi Family buildings must be Net Zero (energy neutral) by 2040
- 2013 California Energy Code is the first step in that direction
- De-aggregation of electrical loads

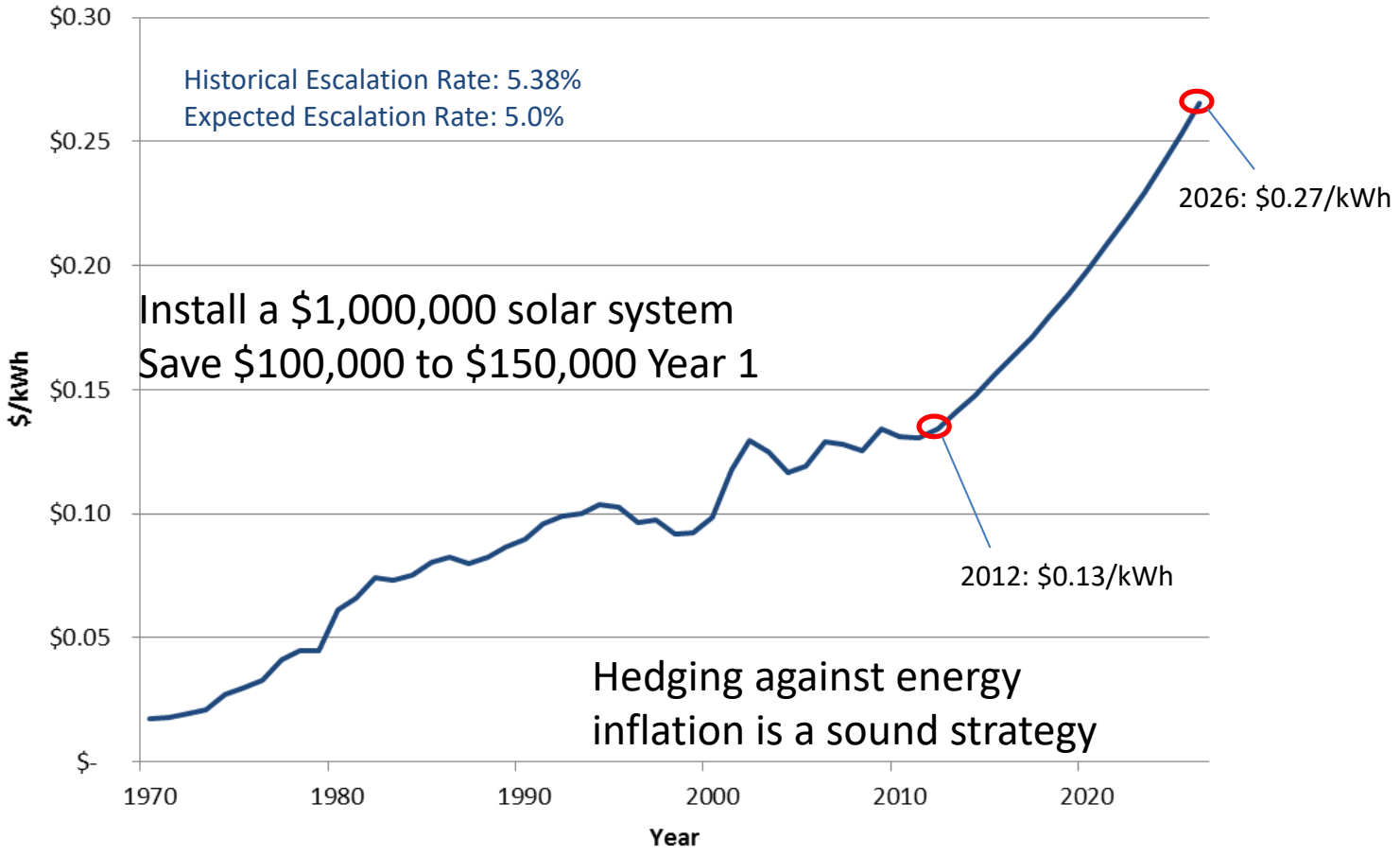


Why Developers Are Planning for Solar

- Construction costs and operating costs have increased, which lowers the property's return on investment
- Developers are looking for ways to improve return on investment due to increased costs
- Safe way to increase return on investment
- Lowers operating expenses (OPEX) and increases Net Operating Income (NOI)
- Increases the overall resale value of the property – often by millions of dollars (200% to 300% of original PV cost)
- Increases owners equity - often by 10%
- Energy projects surpassing real estate investment returns
- Title 24

Electricity Costs to Double In 15 Years

- Historical annual electricity rate escalation in California 5%
- Electricity prices are expected to double in 15 years



Data Source: http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=US#PricesExpenditures

Financial Positives for Developers

- **Lowers operating expenses**
- **Increases Net Operating Income**
- **10 to 15% Return on Investment**
- **Positive cash flow year 1**
- **Asset value increases**
- **Leveragability increases**
- **Very long term benefit, solar lifespan 30 years**
- **ROI on energy investments consistently are higher than for core real estate**
- **Marketability**

- **Example**
  - Install a $1,000,000 solar system
  - Save $100,000 to $150,000 Year 1

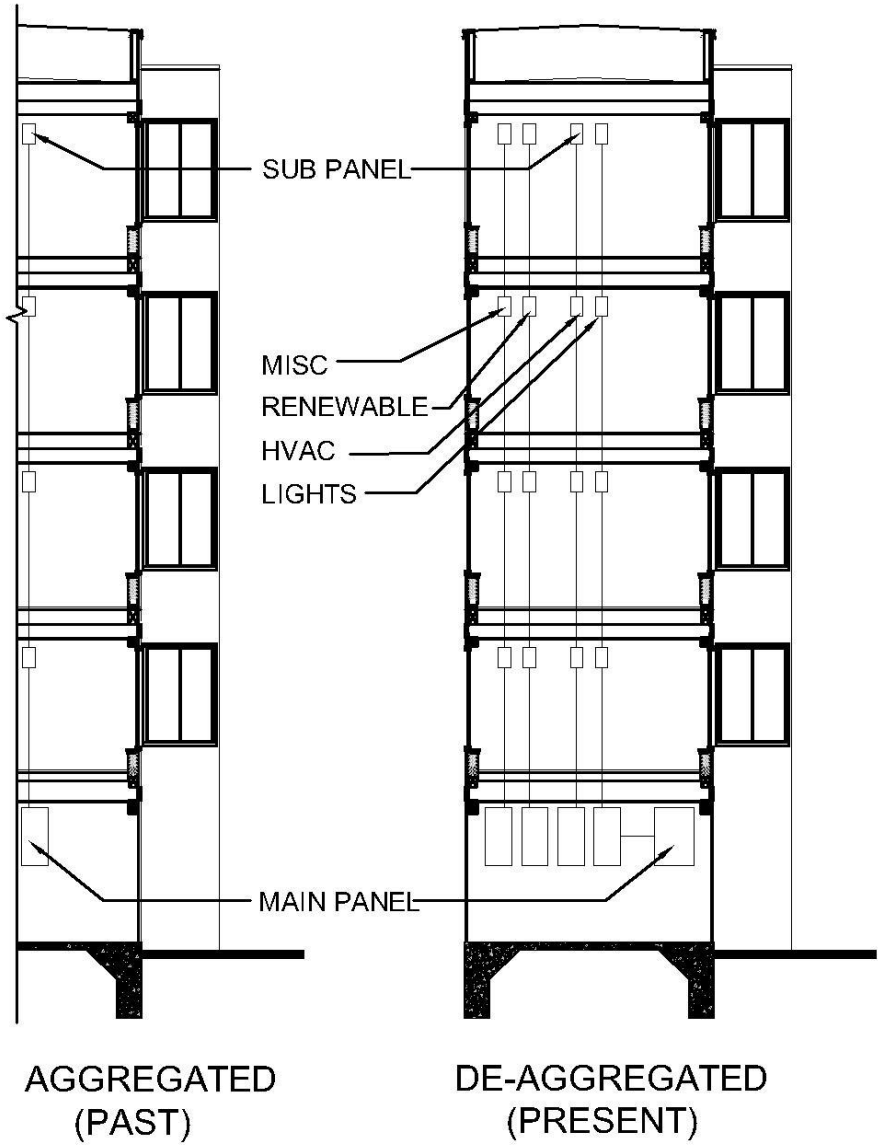
Architects, Planning for Solar & Title 24

- Compliance with 2013 CEC for performance based calculations
- Trade-off less efficient building components for solar PV
- Reduce cost of glazing induced by CEC requirements for double thermally broken windows and low SHG
- Can allow in increase in use of glazing for commercial and residential buildings
- Required for Title 24
- LEED
- Energy Star
- Responding to Developer and Market Demands

Major Changes In California Energy Code

2013 Code	By 2040 (Title 24 Plan)
15% of roof area for solar PV • Commercial < 3 Floors • Apartments/Hospitality <10 Floors	Commercial & Multi Family Buildings must be Net Zero Energy!
Solar Zones defined as 80 SF contiguous area for <10,000SF roof; 160SF for roofs > 10,000SF	Building must produce as much energy as they consume
CD's show panels, inverters, conduit homerun, electrical system, meters	Increased solar roof area will be mandatory
Code allows tradeoff for solar to allow more glazing % for offset	Radical changes!

De-Aggregated Metering Requirements



Solar Engineering and Design

- **Planning roof top space and resolve conflicts**
- **Building orientation-Azimuth**
- **Shade Studies**
- **Racking systems designs and clearances**
- **Roof Top or Parking Structure/Lot Plan**
- **Structural Engineering**
  - Attachments, Seismic, Wind
- **Electrical Engineering**
  - Utility Rule 21, Meters loads, Design and Placement, Procurement
- **Financial Engineering**
- **Mechanical Engineering and Energy Modeling**
- **System Integration into Building Envelope and Risk Mitigation**

Two Case Studies: Multi-Family Apartments

1. Garden style multi-family:

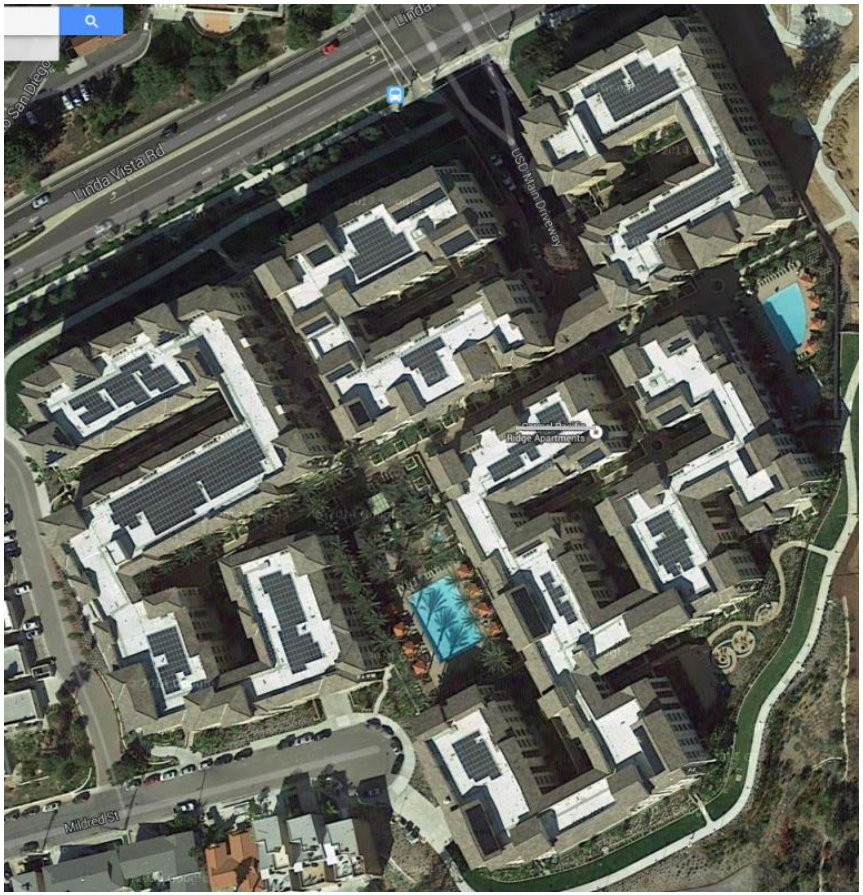
1. Solar PV design to produce 50% of the <u>entire</u> site's electric usage per local code

2. Urban mid-rise:

1. Limited roof space
2. Very energy dense
    1. Energy/Roof SF
3. Solar PV design produces 35% of the <u>common area</u> energy

Case Study 1: 533 Units, New Construction

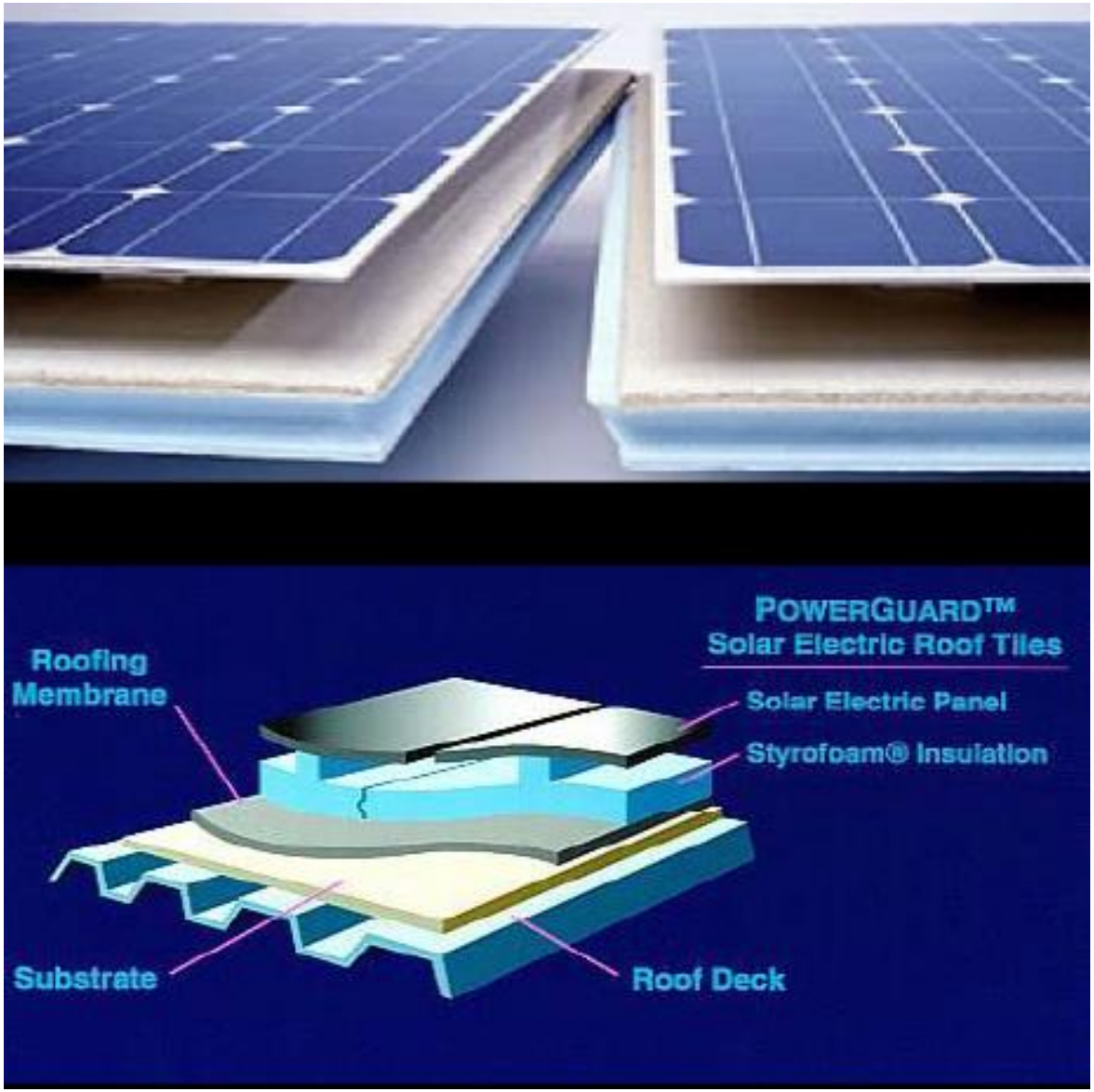
- Garden style multi-family
- Roof design maximized area for solar PV
- Design achieved 50% energy production for the entire site – common area and residential



Case Study 1: Solar Panel Layout

Case Study 1: Mechanical Units and Vent Layout

Case Study 1: Type of Ballasted System



Case Study 1: Ballasted System

Flat Ballasted

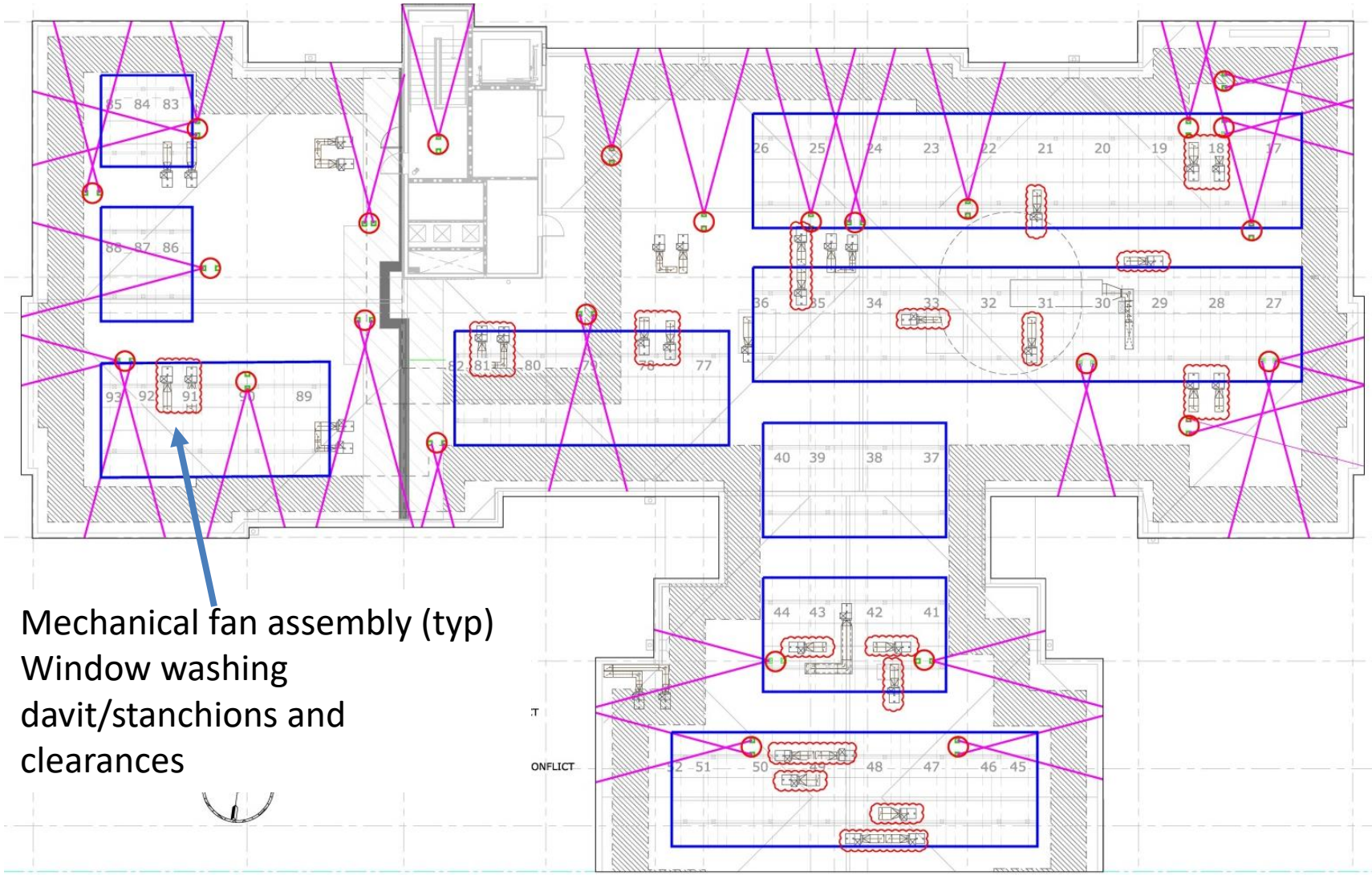
Concerns:

1. Roof Drainage
2. Materials Incompatibility
3. Roof Maintenance
4. Re-roofing
5. Solar Cleaning
6. CalFire

Case Study 2 – Compromise Affects PV Size

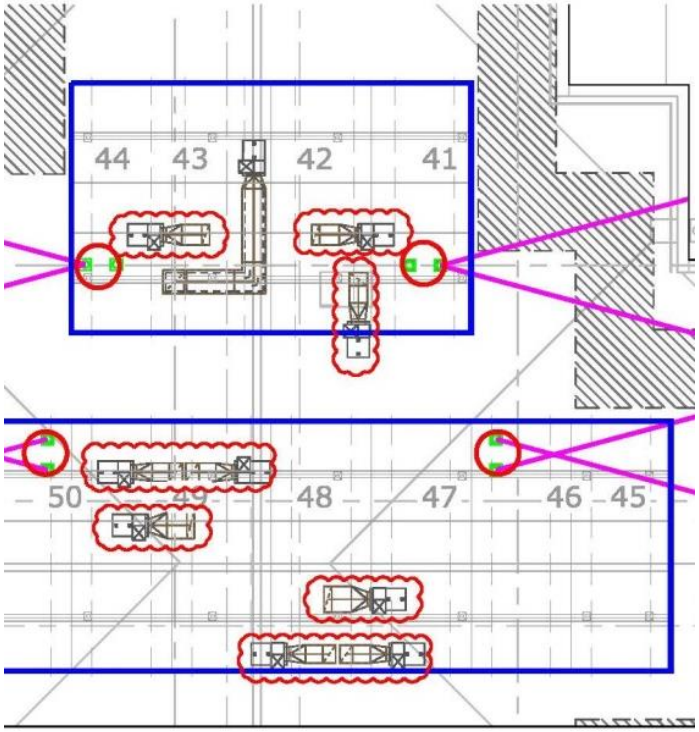
- 6 Story – 250,000 SF urban multi-family development
- 32,000 SF or 295kW of solar PV required for “Near Zero” energy for common area meters
- 22,000 SF or 198kW maximum only in early schematic design

Initial PV Layout With Conflicts



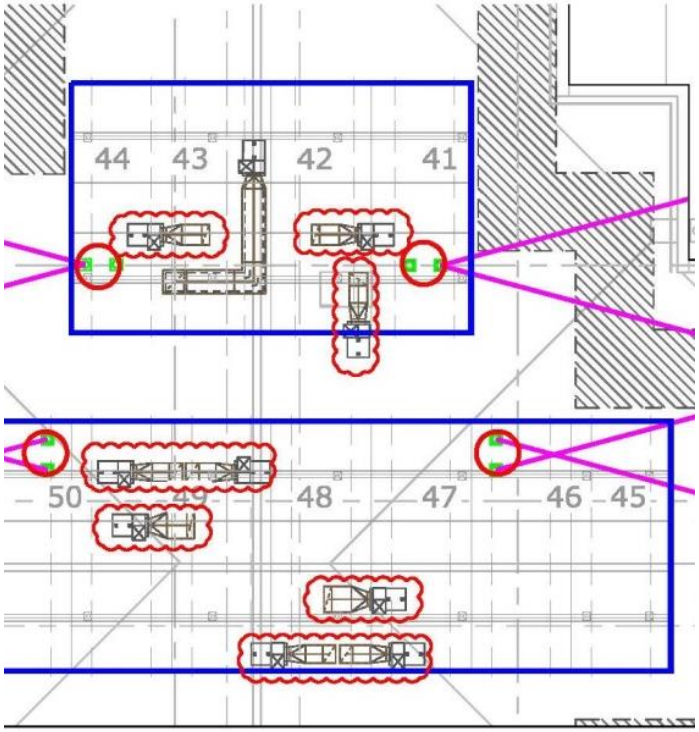
Design Conflict Resolutions-OSHA

Tie back anchors, davits or stanchions for window washing can be relocated to increase space for solar early in planning



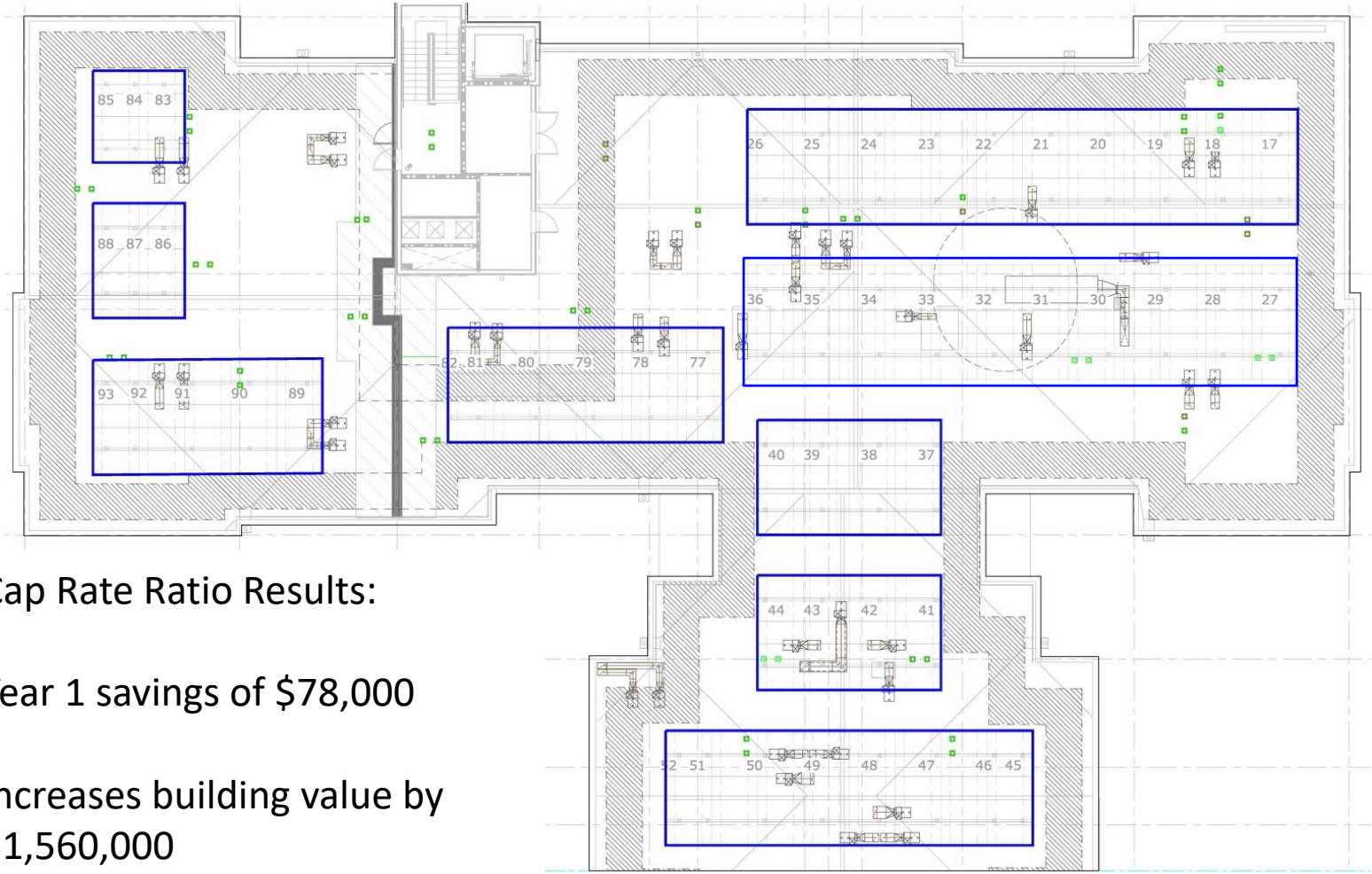
Design Conflict Resolutions-Mechanical

HVAC units and ductwork can be moved to resolve Conflict



Roof is the Real Estate for Solar

- **198kW (22,000 SF) – avoids shading from elevator and stair towers, rooftop deck and parapets**



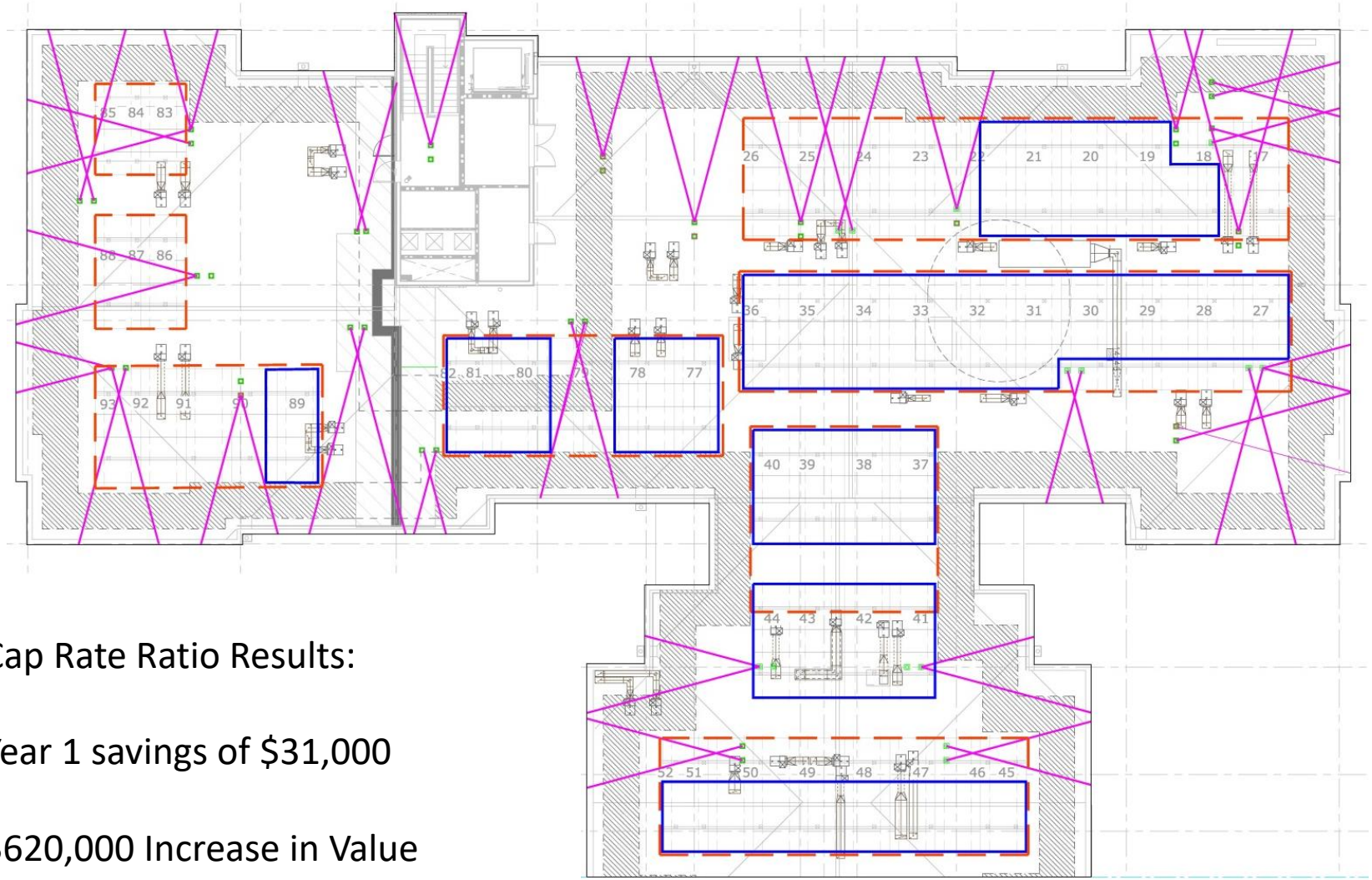
Cap Rate Ratio Results:

Year 1 savings of $78,000

Increases building value by $1,560,000

Option 1: Minimize Solar To Eliminate Conflicts

80 to 100kW PV (11,000 SF). Up to 60% decrease to solar goals



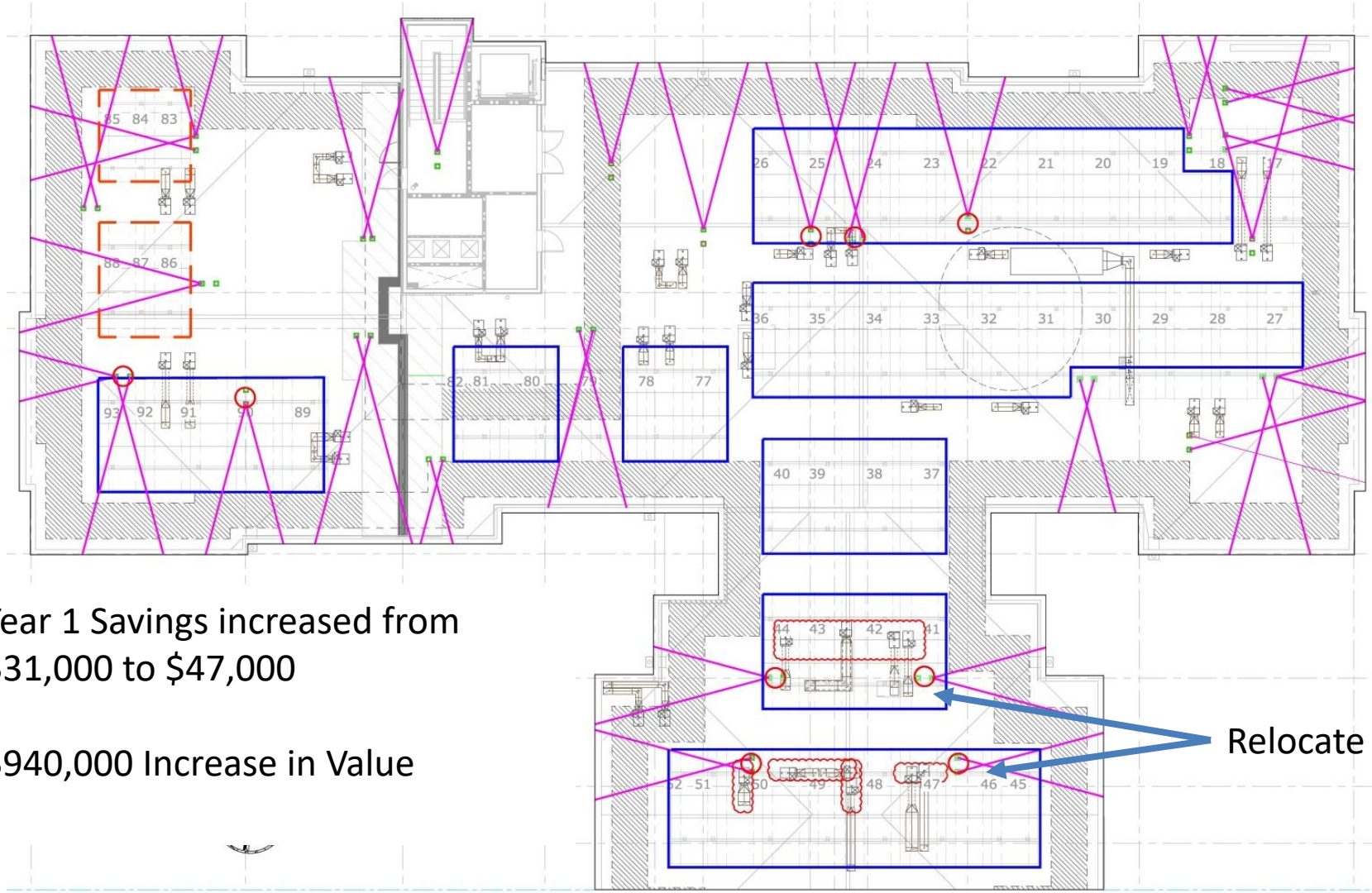
Cap Rate Ratio Results:

Year 1 savings of $31,000

$620,000 Increase in Value

Option 2: Relocate Selected Roof Davits

120kW PV (13,000 SF). 38% Penalty to solar

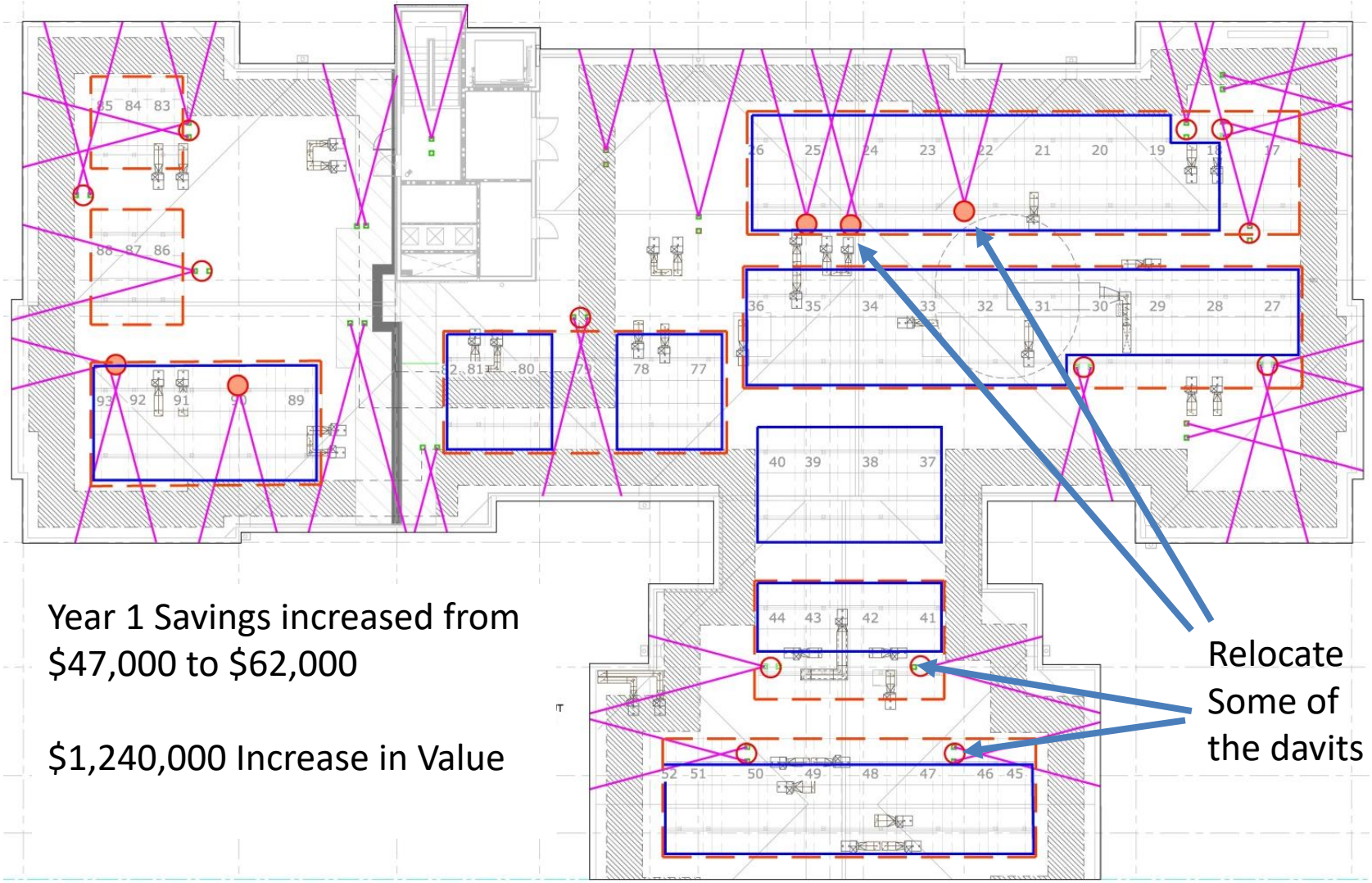


Year 1 Savings increased from $31,000 to $47,000

$940,000 Increase in Value

Option 3: Relocate Davits and Mechanical

- **157 kW (17,000 SF) – Maximum Possible**



Financial Benefit Of Solar

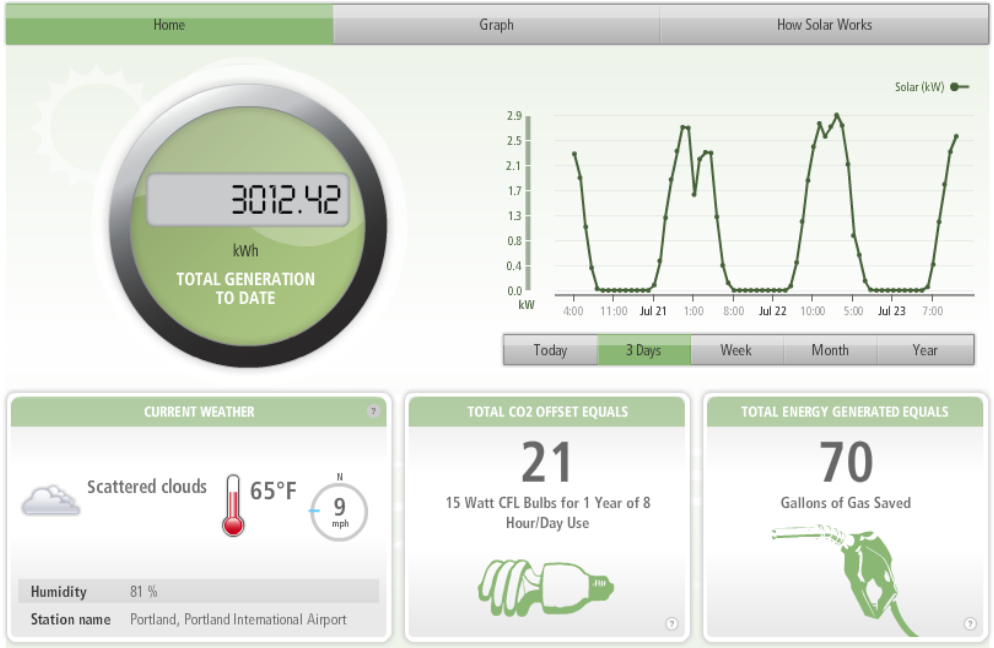
- **Typical example: Offsetting common area energy only**
  - Solar gives you a valuation increase of $3 for every $1 you spend.
  - >2% increase in the total value of the property
  - >8% increase in owners equity

- **First example: Offsetting 50% of the entire site energy**
  - Includes Solar Powered Apartments
  - Valuation increase of >$3.5 for every $1 spent
  - >3% increase in total value of property
  - >12% increase in owners equity

Financial Benefit Of Solar For 50% Of Site

- **Triple Bottom Line**
  - Owner earns an excellent profit on the additional investment
  - Tenants receive solar energy for cheaper than the grid
  - Green power benefits everyone

  - (Solar Powered Apartments Receive Their Own Web Portal)



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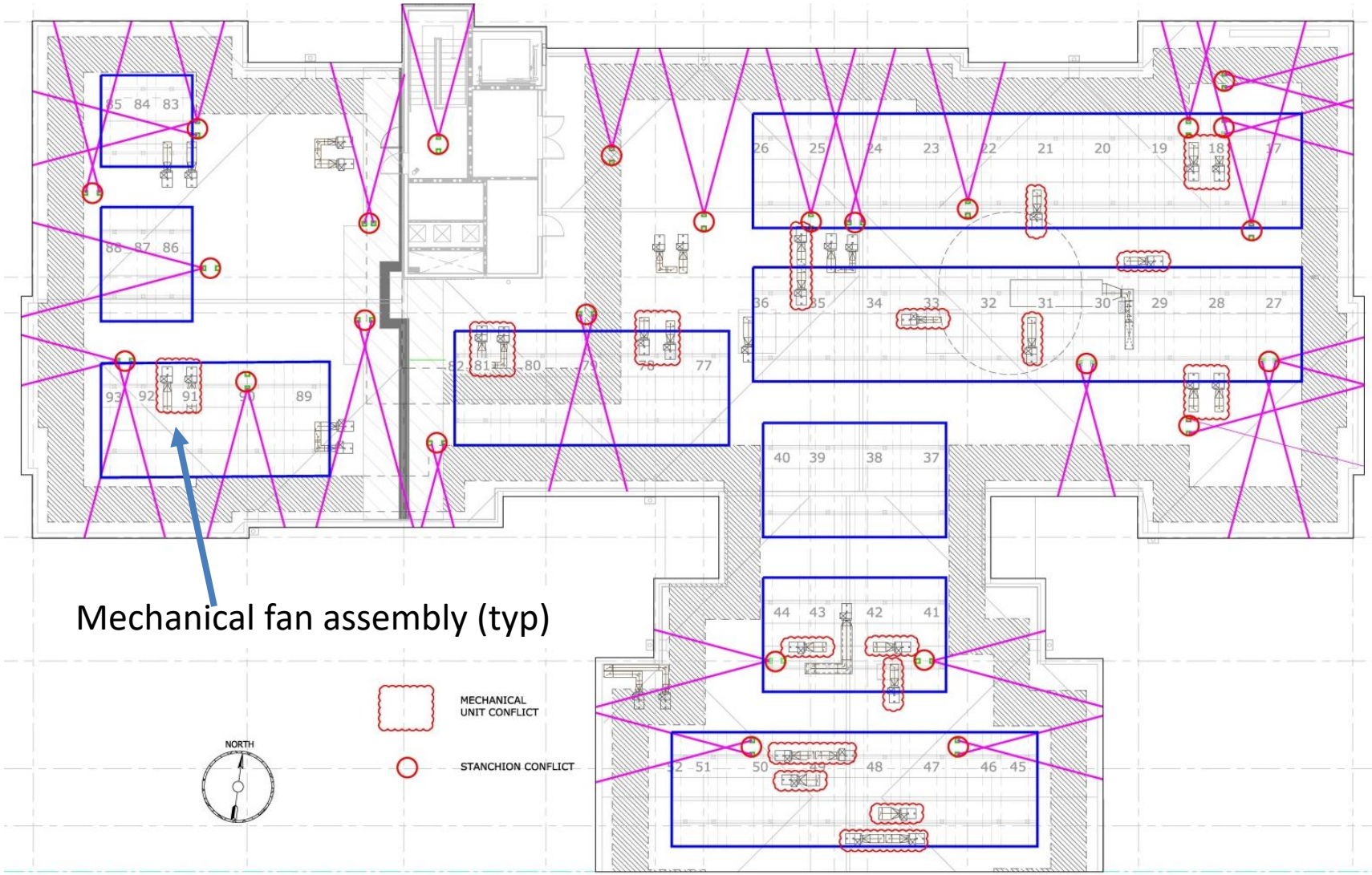
Additional Planning for Solar

Building Orientation-Azimuth

- **Summer afternoon sun is most valuable**
- **Solar friendly roofs should be oriented:**
  - South to southwest in California (180-225 degrees)

This Type of Roof Design Will Not Be Feasible

Planning Solar Panel Layout and Resolve Conflict



Solar PV – Mounting Solutions

- **Roof Mounting and Racking Systems**
- **Attachment to Roof Structure**
- **Ballasted**
- **Tracking Systems**
  - Single Axis
  - Dual Axis
- **Parking Lot Solar Shade Structures**
- **Solar Shade Canopies over Parking Structure Top Decks**
- **Building Integrated PV (BIPV)**

High Rack Attached Racking System

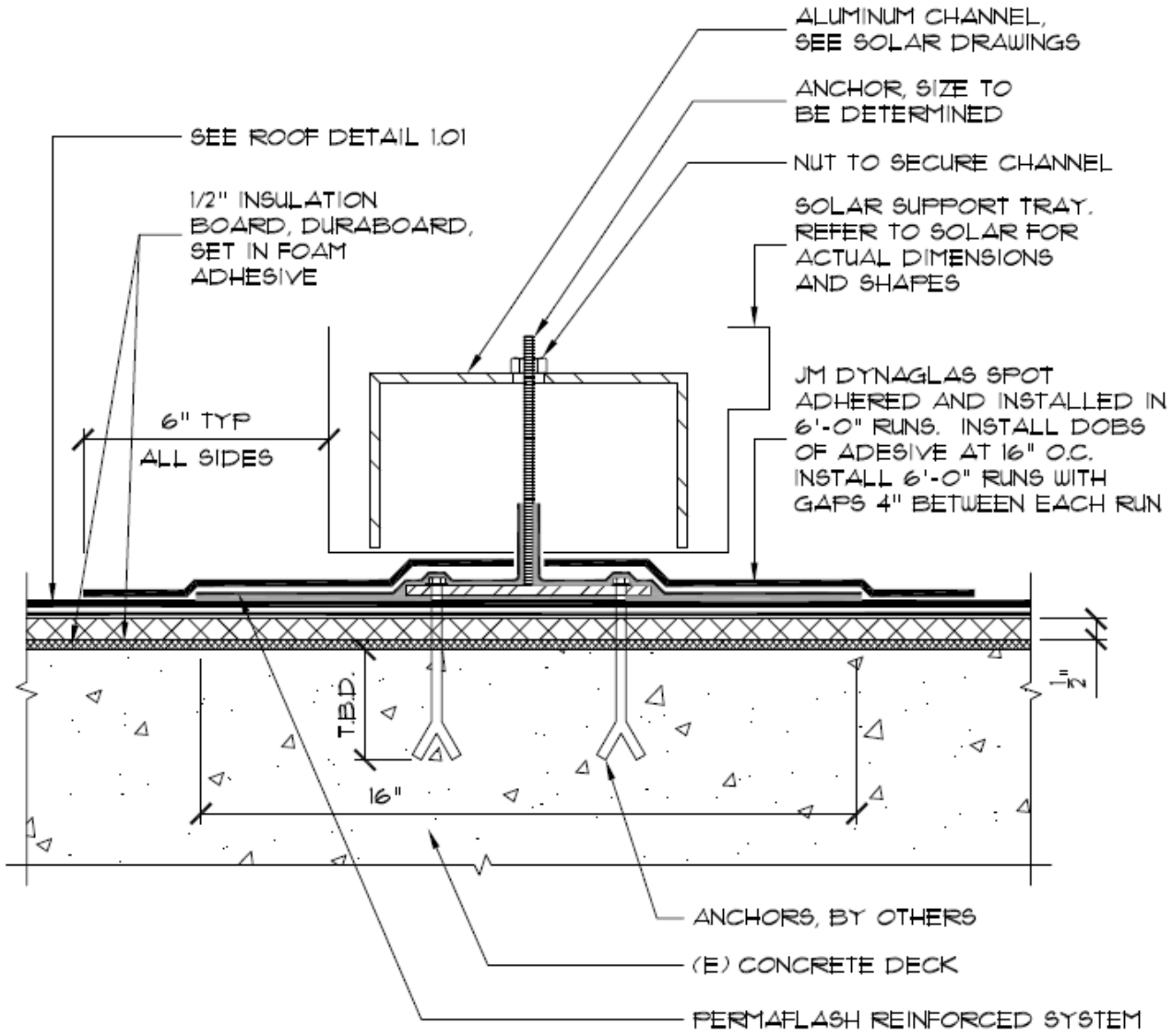
High Rack Attached Racking System

High Rack Attached Racking System

Low/Med Rack Attached Racking System

Ballasted Panel

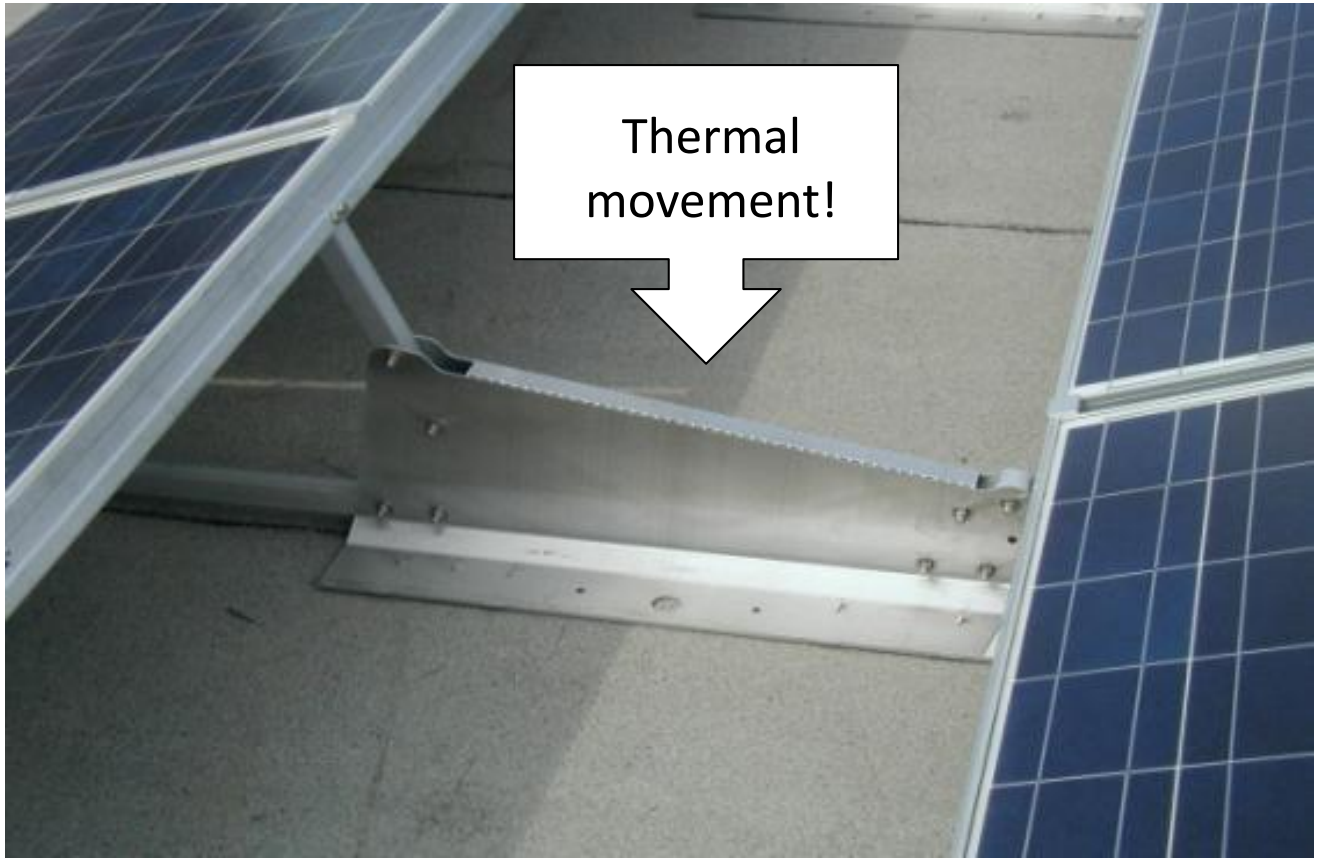
Ballasted Roof Attachment Detail



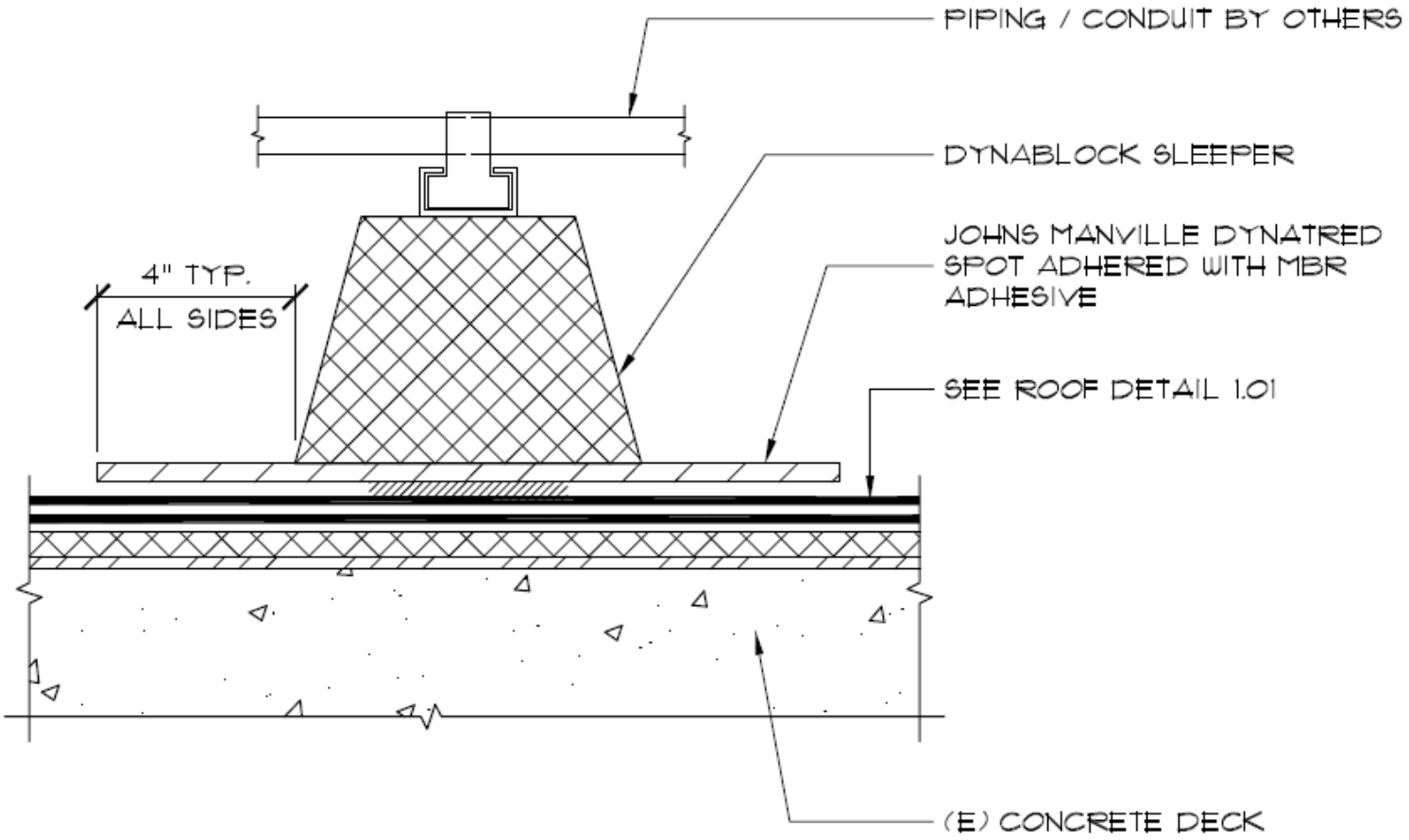
Type of Ballasted Racking System

Engineering and Design – Design Considerations

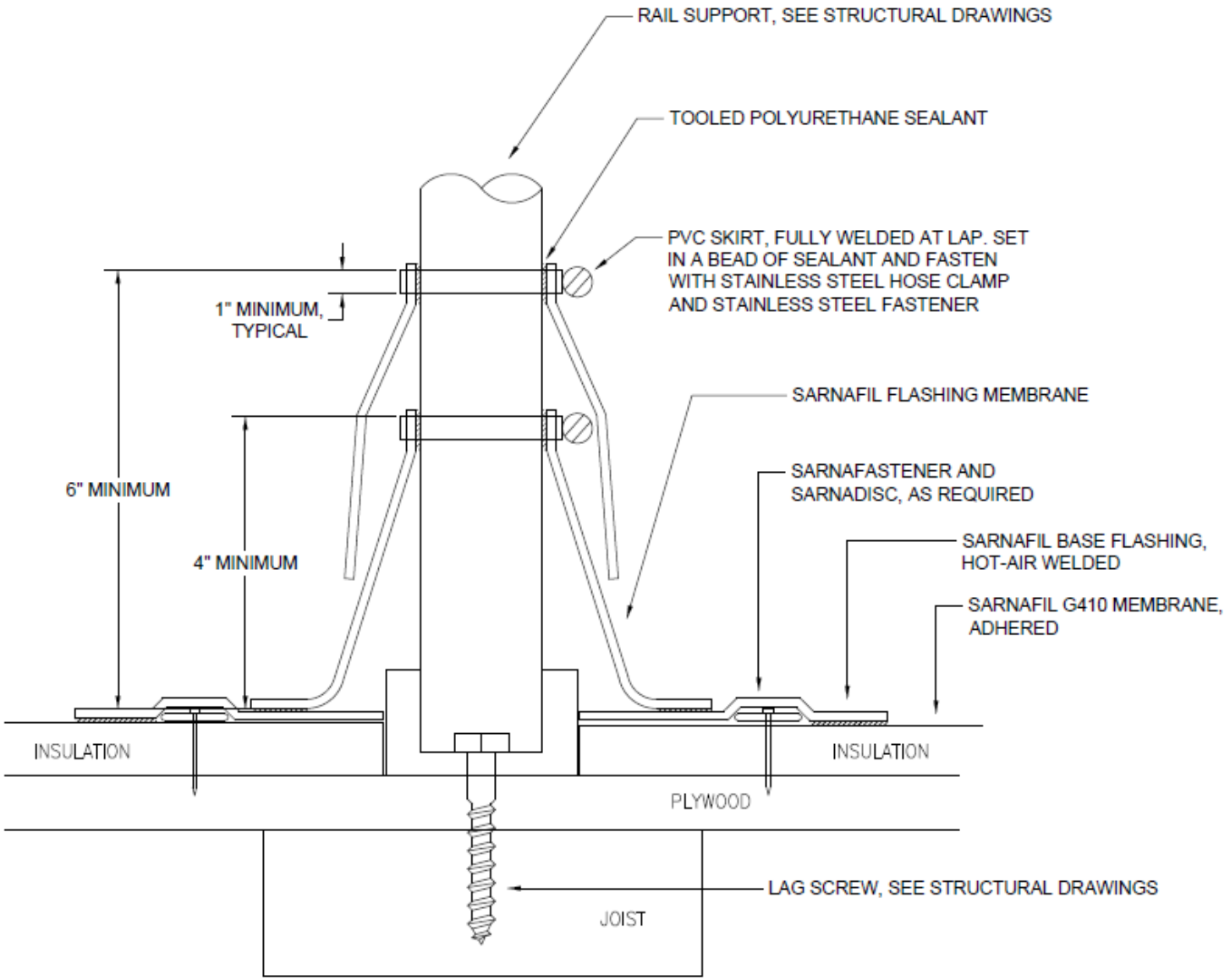
- **Non-penetrating ballasted system**
  - Thermal Movement – Engineering Required
  - Scuffing and abrading roof material
  - Structural Analysis



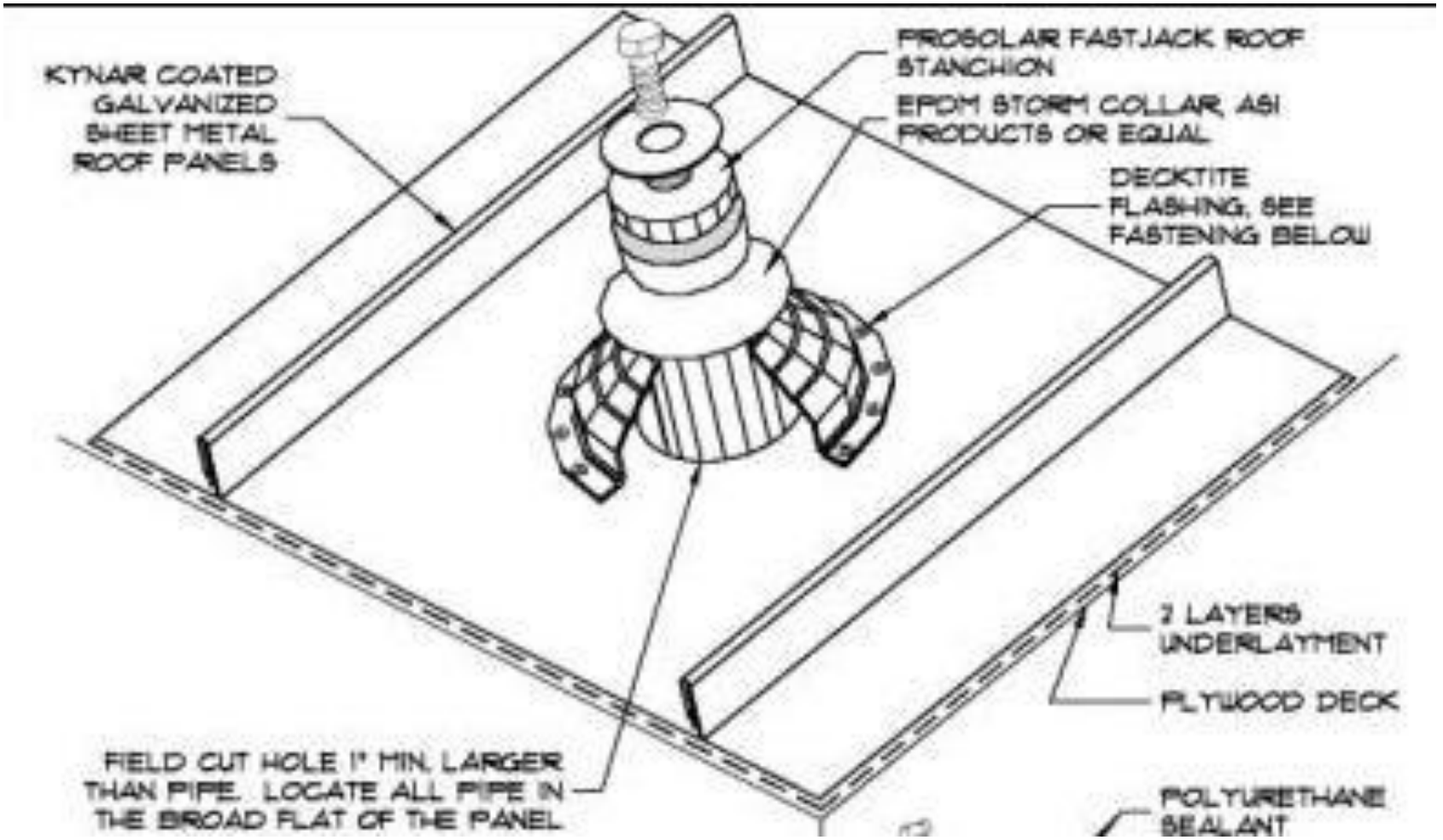
Roof Conduit Detail



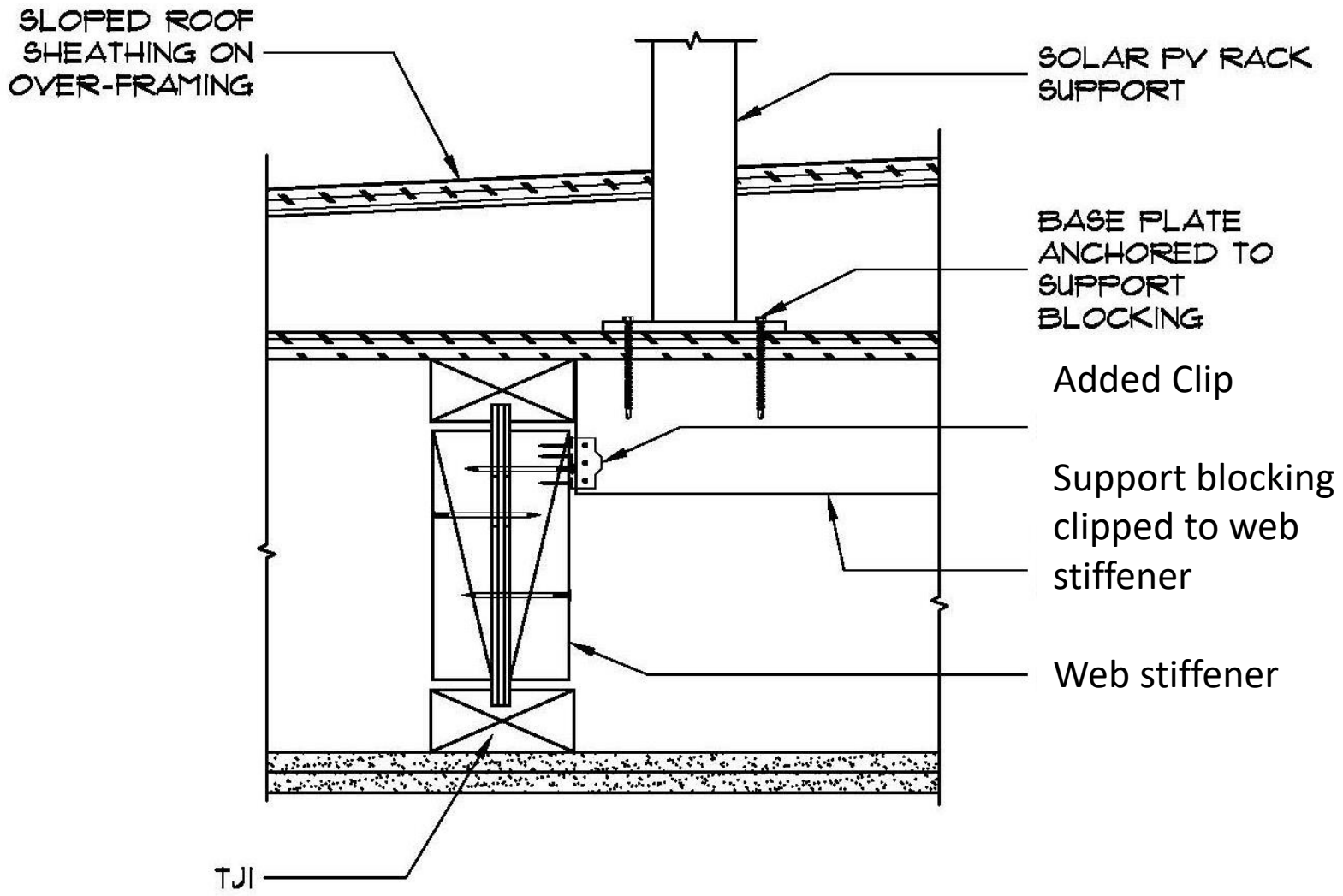
Example of Proper Flashing Detail



Standing Seam Metal Roof Penetration



Structural Blocking for TJI Truss



UL 2703 – January 1, 2015

- **Solar module and racking assembly must pass UL Labs standards and testing and then meet the Fire Rating classification of the roof.**

Underwriters Laboratories

Central and String Inverters

- **Central Inverters**
  - 1 Per System
  - Large footprint
  - Not redundant
  - Efficient

- **String Inverters**
  - Many per system
  - Redundancy
  - Locational flexibility
  - Improves shading response
  - Efficient

Micro Inverters

- **Micro Inverters**
  - 1 Per Module
  - Tiny footprint
  - Not as efficient
  - Excellent for shaded applications
  - Highly redundant

Electrical Rough In

- Conduit from roof to electrical room and point of connection for Utility Interconnection

UL 2703 – January 1, 2015

- **Solar module and racking assembly must pass UL Labs standards and testing and then meet the Fire Rating classification of the roof.**

Underwriters Laboratories

Financial and Electrical Engineering Blended with Friendly Utility Billing Tariffs

- **If insufficient roof space…**
- **Customizing loads for solar PV to optimize financial performance may be required**
  - Lighting loads
  - Elevator loads (multifamily only)
  - Other non peak-heavy loads
- **Solar-friendly electrical loads that are used during morning and evening to optimize energy savings**
- **Allows the solar to spin the meter backwards during the daytime for net metering**
- **Complex energy and financial modeling required for accuracy**
- **Understanding metering options and optimizing**

Utility Net Metering Options

- Net Energy Metering (NEM) allows bi-directional meter to be installed that will be able to spin backwards to accrue credits at the retail value when produced which allows for systems to use these credits when the sun is not shining

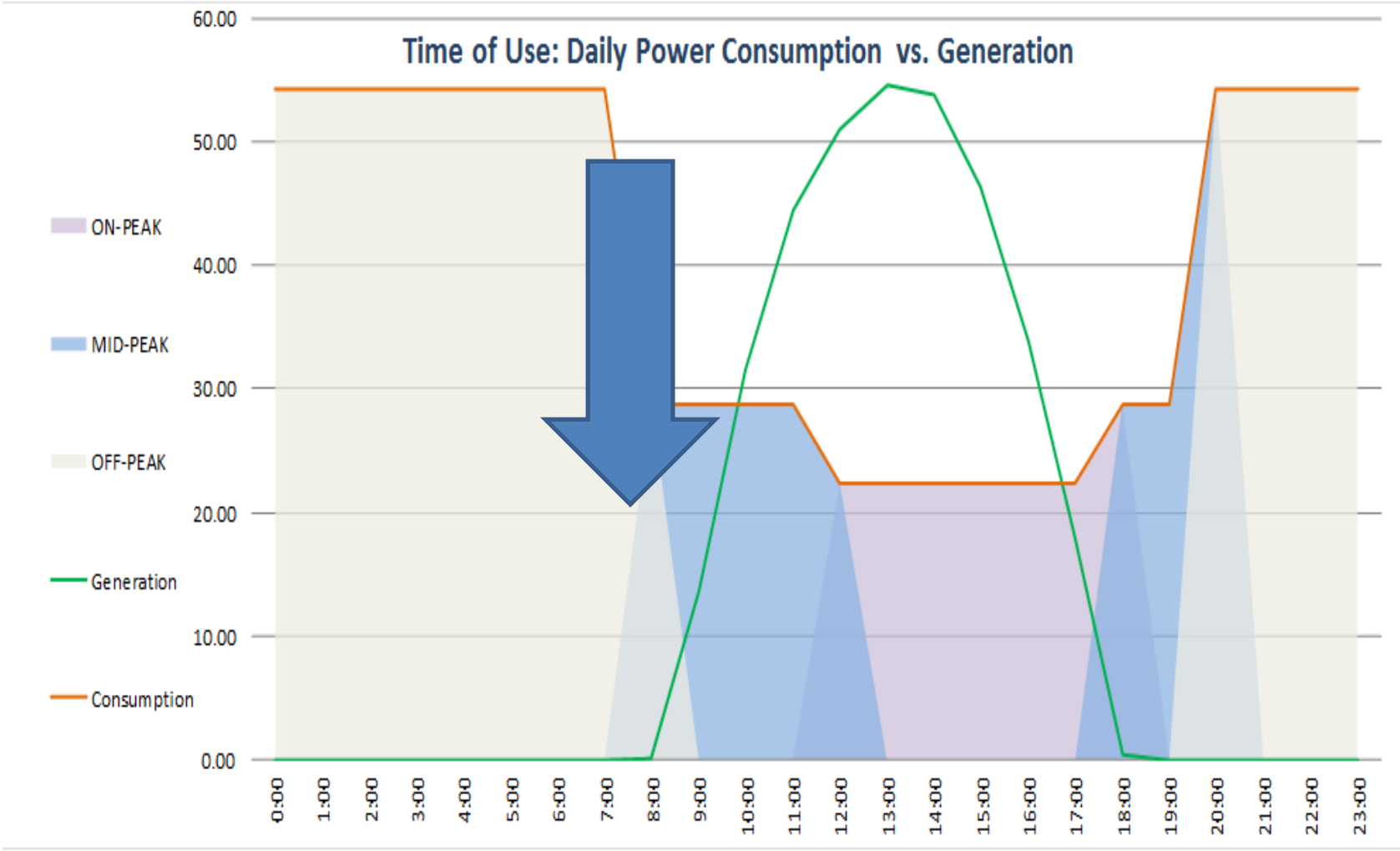
- Net Energy Metering Aggregation (NEMA) also known as Aggregated Net Metering or Meter Aggregation, allows a single, centralized solar panel system to service multiple meters/service points.

- Virtual Net Metering (VNM) is a tariff arrangement that enables a multi-meter property owner to allocate a solar system's energy credits to other tenants.

Load Profiling

Time of Use

Annual kWh Consumption 349,190 Annual Generation 141,370



Solar Commissioning - Basics

- A commissioning agent should be an independent third party.
- Commissioning confirms that the system was constructed and installed in conformance with the contract documents and that it is performing as engineered.
- The installing contractor cannot be a commissioning agent because they have an inherent conflict of interest.

Solar Commissioning Identifies:

- **Bait and switch**
  - Materials have not been replaced from original specifications to save money
- **Identifies and Verifies:**
  - Hot spots within the system (using thermal imagery)
  - Correct torque settings
  - Correct inverter settings
  - Verification of as-built plans
  - Correct labeling
  - Roof impacts
  - Code violations
  - Risk

Importance of Maintenance

- Warranties - which may not be honored if no proof of proper maintenance is documented
- Inverters fail prematurely due to excessive heat build-up
- Photovoltaic systems are designed to last 30-40 years with maintenance program NOT without.
- Simple problems may reduce the life expectancy of the PV system
- Without proper inspection and cleaning, production will diminish
- According to the National Renewable Energy Laboratory, soiled modules can show a deficiency of 25%-40%
- Soiling affects solar modules as well as electrical equip.

Importance of Maintenance

Excessive dirt build-up on PV modules creates "Hot Spots".
Can cause cell series wiring to prematurely fail
and VOID the manufacturer's warranties

Problems for the Solar PV Industry

- **Design and construction defects are rampant in waterproofing and building envelope**
- **Solar systems are often poorly designed and integrated into the building envelope**
- **Poor workmanship and electrical issues**
- **Results:**
  - Electrical failures, water intrusion, and attachment failures
  - System performance and uptime are impaired, often critically

Common Failures

- **Communication with building owner/operators**

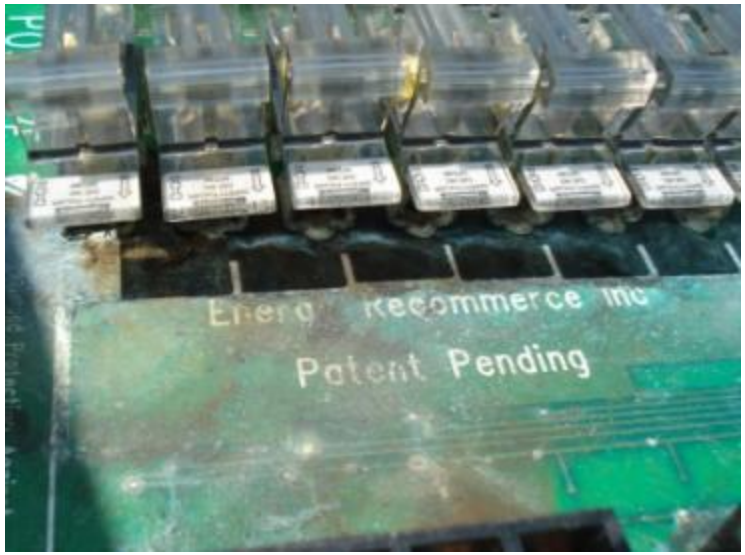
- **Waterproofing**
  - Improper flashing
  - Incompatible materials

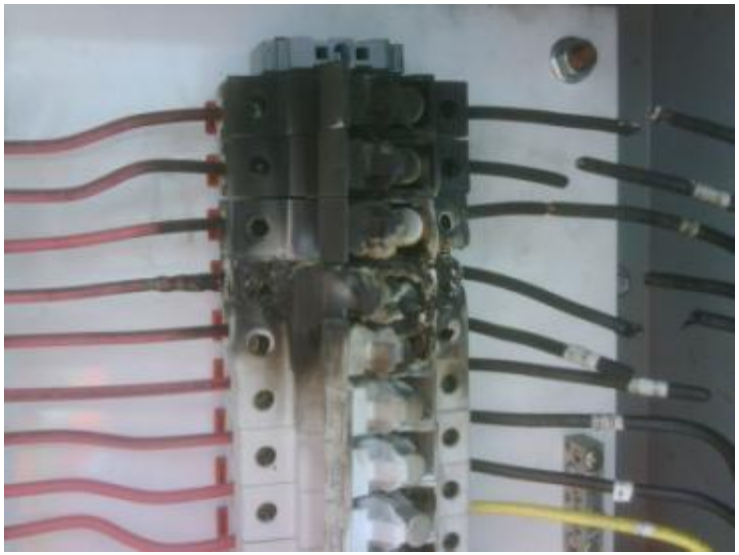
- **Thermal movement**

  Contraction and expansion:
  - **Fasteners** – attachment and safety concerns
  - **Flashings and seals** – water penetration
  - **Buckling** - attachment and safety concerns
  - Racking thermal movement can be perpendicular to deck thermal movement!

Where is the Flight to Quality?

If this project was handled properly from the beginning, would these things have happened?





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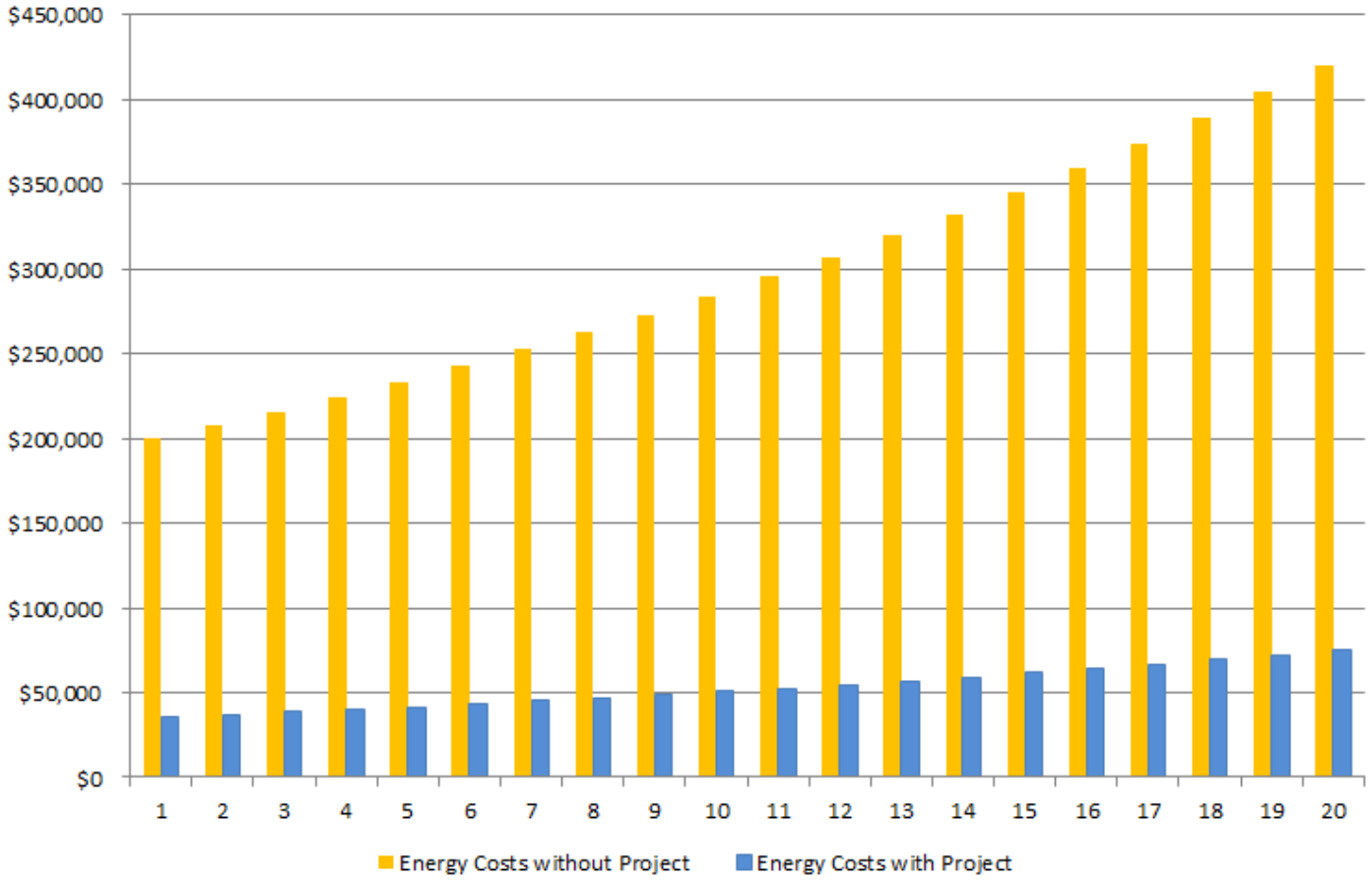
Financial Benefits of Solar

Solar Economics

- Up to 95% reduction in electricity costs
- Tax benefits and incentives reduce cost of solar technologies by more than 50%



More Basic Economics

- Every $1,000 in annual electricity expense can be offset by a 2.5kW to 4.0 kW PV system
- This is equivalent to 250 to 400 SF of rooftop solar needed for every $1,000 in annual electricity expenses
- To offset $100,000 in electricity expense, you need 25,000 SF to 40,000 SF of solar

Solar Increases Property Value

If you're selling the property, it improves the resale value

- **For every $1 invested in solar PV, you increase the property value by $2 to $3.**
- **A $1,000,000 solar project will increase resale value by $2,000,000 to $3,000,000**
- **Every $50,000 in energy savings from solar equals $1,000,000 increase in property value**
- **Improved leveragability**

- **Capitalization Rate (or "cap rate") is the ratio between the net operating income produced by an asset and its capital cost (the original price paid to buy the asset) or alternatively its current market value**

Solar Increases Investor Equity

- Developers typically have 20 to 25% equity in properties and borrow 75 to 80%
- The additional value from solar flows to the bottom line
- And causes an 8 to 12% INCREASE in investors equity
- If an owner borrows 75% to install solar, the power of leverage multiplies their cash investment 9 TIMES

Unique Financing Programs

- **Property Assessed Clean Energy (PACE) Financing**
  - Zero up front capital required
  - Special property tax assessment – repaid over 20 years
  - Can be used for solar and anything energy related like cool roofs
  - Off balance sheet (developers love this!)
- **Power Purchase Agreements**
  - Zero up front capital required
  - Pay for the energy generated by the solar system
  - ~20% discount to your current cost of power
  - Off balance sheet

Summary of Financial Benefit of Solar PV

- **Increase Net Operating Income (NOI)**
- **Increase property valuation instantly (2X cost)**
- **Improves property Return On Investment**
  - Return on Investment (ROI) for solar of 10% to 16%
  - Core real estate ROI of 5% to 7%.
- **Tax benefits and incentives can reduce cost of solar by more than 50%**
- **2 - 3% increase in building value**
- **8 - 12% increase in owners equity**
- **Unique financing programs require zero up front capital**

Questions