Home Performance for Solar Professionals and Solar Decision Makers
Introduction
Welcome to Home Performance for Solar

Who am I?

• Home Energy Nerd
• Passionate Environmentalist
• 15+ Years in Solar and Cleantech
• 10 Home Energy / Solar Certifications
• Energy Auditor – 1000+ Energy Audits
• General Contractor, Electrician – 100+ Whole Home Upgrade
• Solar Consultant for Leading San Diego Based Companies
• Regional Manager for Enphase Energy
Outline for the Course

1. What does a value-based transaction look like in the solar industry?
2. Why home performance can have such a big impact on a solar project?
3. What are some of the basic principles of home performance?
4. What is the approach you can use to understand where the opportunities are?
5. What solutions are the most commonly effective on the efficiency side?
6. What is the future vision for the home’s energy systems?

Summary: What are the highlights from this course that will enable the design of great home energy projects.
Welcome to Home Performance for Solar

Learning Objectives

At the conclusion of this training, participants will be able to...

1. Assess any solar energy project through a “whole home” approach.
2. Apply new tools to increase value created through any solar energy project.

Bonus:

What does a value-based transaction look like in the solar industry?
Why are we talking about value here?

• Today we have solar professionals and homeowners together!!!
• Ultimately there will be a certain level of value for each project.
• This value is creating by the homeowner and the solar professional.
• By understanding:
  1. Reality
  2. Homeowner’s Goals
  3. Pathways to Achieve Goals

The VALUE in a transaction can be maximized!!!
What kind of solar transaction are you creating?

• **Win / Lose Transaction?**
  • Homeowner gets a good price on equipment, but the installer loses money.
  • Installer sells solar system at a high price; customer doesn’t get a great payback.

• **Lose / Lose Transaction?**
  • Homeowner gets a good price, but the installer goes out of business.
  • Installer sells solar system at a high price; customer doesn’t refer more business.

• **Win / Win Transaction?**
  • System is sold for a fair price; homeowner gets a ton of value!
  • System performs over time; professional is around to support project!
  • Opportunities planned for with original project are fulfilled on!
Where is value derived in a solar transaction?

• Savings
  • Year 1 Energy Savings / Utility Bill Savings
  • Lifetime Energy Cost System Savings
  • Savings in Reduced Up-Front System Costs
  • Savings in Deferred Maintenance Costs

• Improved Quality of Life
  • Freedom to operate home comfortably
  • Resilience and energy security in the face of blackouts
  • Happiness & fulfillment even?
How do you maximize that value?

• By seeing opportunities and interdependent relationships that others miss
• By educating (getting educated) about those opportunities
• By evaluating the design incorporating these potential opportunities
• What can this include?
How does this work in terms of design?

Value

Homeowner
- Home
- Goals
- Resources

Professional
- Solutions
- Rebates
- Financing
What does this mean for the...

Homeowner

Be Curious
Be Clear
Be Responsible

Professional

Align
Problem Solve
Add Value
Impact: Why home performance can have such a big impact on a solar project?
Why Home Performance?

- A higher performance home uses less energy.
- A higher performance home is more comfortable.
- A higher performance home is safer.
- A higher performance home has more options.
- A higher performance home lasts longer.
- A higher performance home is...

Better positioned for a solar energy system!
Why does less energy = better positioned for solar?

• Less energy means a smaller systems size which can mean...
  • Lower investment,
  • Better roof orientations for production,
  • Better roof location for aesthetics,
  • Less requirement to use a high-efficiency panels (more $ panel),
  • More space for future system add-ons,
  • Less roof penetrations,
  • Less re-roofing work to do,
  • Less chance you’ll need to upgrade your main service panel,
  • A smaller energy storage system required,
  • More protection against rate changes...
What Solar Energy Misses...

• A solar energy system is only the fuel, it’s not the machine.
• A solar energy system can rarely really fix a home comfort problem.
• A solar energy system can rarely make a home safer.
• A solar energy system only generates energy approx. 6 hours per day.
• A solar energy system is almost never the upgrade with the #1 ROI.
• A solar energy system is one part of the picture.
Concepts and Theory:
What are some of the basic principals of home performance?
Whole Home Approach

Building Science / Home Performance

• Everything works as a system.
• Big picture thinking will save you money now and in the long run.
• Examples:
  • Insulation & air sealing -> Reduce HVAC Usage -> Reduced Solar (Especially during TOU)
  • Ducting & HVAC -> Reduce HVAC Usage -> Reduced Solar (Especially during TOU)
  • Solar & Roofing -> 30% Tax Credit on Roofing Required -> Reduced Future Repairs
Energy Use & Comfort

- A home’s energy usage is not the ultimate measurement of that home’s efficiency.
- Homeowner’s conservation may be the deciding factor, not their home’s efficiency.
- A high-performance home will stay cool and comfortable in the summer and warm and cozy in the winter with reasonable energy bills.
- Solar does not always off-set all the benefits you can achieve through a high-performance home.
Conservation vs. Efficiency

• Energy Conservation: The decision and practice of using less energy.
  • Turning off lights
  • Using less heating and air-conditioning
  • Unplugging appliances
  • I’m not a big proponent of suffering these days

• Energy Efficiency: Reducing the amount of energy required to provide a service.
  • Incandescent lights -> LEDs
  • Leaky ducting -> tight ducting
  • 10 SEER AC -> 16 SEER AC
  • Typically a one-time change / investment...ongoing results without effort
3 Forms of Heat Exchange

- **Conduction** – The transfer of heat (energy) from one substance to another through direct contact. (colliding molecules)
- **Convection** – The transfer of heat (energy) through a fluid caused by molecular motion. (moving molecules)
- **Radiation** – The transfer of heat (energy) through a vacuum in the form of rays or waves or particles. (moving particles)
2\textsuperscript{nd} Law of Thermodynamics

- **The second law** generally states that isolated systems gravitate towards *thermodynamic* equilibrium.
- Heat energy will flow from the hotter to the cooler object.
- Objects (areas) will exchange thermal energy until thermal equilibrium is reached, i.e. Until their temperatures are equal.
- What does it take to keep things out of equilibrium? External Energy
Does Heat Really Rise?

• Heat flows from hot to cold...so why have I heard the phrase hot air rises?

• Density...
  • The molecules jiggle and zip around faster in hot air. This causes them to spread out. When molecules spread out, they are less dense (lighter) than a denser group of molecules and thus rise.

• Hot air rises....in most cases.
  • When cool air sinks inside a home, hot air can fall from outside.
Humans are Radiant Creatures

- The majority of our heat loss is through radiant heat loss...(45% - 70%.)
Building Science 101 – Air Sealing

Air Sealing

Insulation + Air Barrier = Thermal Envelope
Insulation

- Insulation reduces heat loss through conduction.
- R Value = Resistance Value
- The higher the R-Value the slower the heat loss through conduction.
- You want to think about insulation as something that slows the transfer of heat between two surfaces through conduction.
Insulation

- Heat travels the path of least resistance.
- \[ U \text{ Total Area} = (U \text{ Value} \times \% \text{ of Area}) + (U \text{ Value} \times \% \text{ of Area}) \]
- Example 1: R-30 on 50% / R-0 on 50%, Total =
- Example 2: R-30 on 95% / R-0 on 5%, Total =
- Example 3: R-30 on 80% / R-5 on 20%, Total =

- R=2 (94% Loss)
- R=12 (59% Loss)
- R=15 (50% Loss)

- Insulation is only as effective as it’s installed!!!
Power vs. Energy

• **Power**
  - “The rate at which work is (can be) done.” In this context: The rate of producing or consuming energy.
  - In any given moment...
  - Typical Units = Kilowatts, Watts...
    - Note: A Kilowatt = 1000 Watts

• **Energy = Power x Time**
  - “The capacity for doing work.” In this context: Energy is what you use or produce and it’s what residential customers pay for.
  - Power used over a period of time.
  - Typical Units = Kilowatt Hour (kWh), Watt Hour (Wh)
Power vs. Energy (Examples)

- Six 65 Watt light bulbs (Power) are operating for 8 hours.
  - \((6 \times 65 \text{ Watts} = 390 \text{ Watts})\)
  - \(390 \text{ Watts} \times 8 \text{ Hours} = 2,340 \text{ Watt Hours} = 2.3 \text{ KiloWatt Hours (2.3 kWh)}\)

- Ten 330 Watt solar panels (Power) are producing at max output for 5 hours.
  - \((10 \times 330 \text{ Watts} = 3,300 \text{ Watts})\)
  - \(3,300 \text{ Watts} \times 5 \text{ Hours} = 16,500 \text{ Watt Hours} = 16.5 \text{ KiloWatt Hours (16.5 kWh)}\)

- A Battery’s Storage Capacity is 9 kWhs (Energy) and it’s maximum discharge rate is 3 kWs (Power).
What is the approach you can use to understand where the opportunities are?
Whole Home Approach

Building Science / Home Performance

- Everything works as a system.
- Big picture thinking will save you money now and in the long run.
- Examples:
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  - Ducting & HVAC -> Reduce HVAC Usage -> Reduced Solar (Especially during TOU)
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Seasonal vs. Baseline Usage
Seasonal vs. Baseline Usage

- **Baseline Loads:**
  - Lighting
  - Pool pumps
  - Plug loads

- **Seasonal Loads:**
  - Air conditioning
  - Heating
  - Misc.
Solutions:

What solutions are the most commonly effective on the efficiency side?
Baseload
Lighting on average will account for 10% of your electricity usage and approx. 20% of your baseload electricity usage.

- LEDs typically use 1/6th – 1/10th of the electricity of a incandescent and 2/3rd – 1/2 of the electricity of a CFL.
- I used to say only high-use areas...now I recommend everywhere.
- LEDs are designed to last 25 Years.
- Sometimes I hear people say I’m replacing as I go...
  That will actually cost more money than doing it now.
- Cost has plummeted and light quality has greatly improved.
Lighting - LEDs

• Color:
  • Color is measured in Kelvin (K). 2700 K, 3000 K, 3500 K, 5000 K, 6000 K, etc.
  • 2700 K is Warm -> 5000 K is Cool.
  • How does this correspond to human experience?

• CRI:
  • Accuracy of light.
  • CRI of 90+ is recommended...the higher the better.
Refrigeration / Appliances

• An old fridge (main or garage fridge) is usually the biggest offender.
• Payback typically works for a fridge replacement.
• Let’s do some math:
  • An old fridge may use approx. 1000 kWh per year while a new fridge may use 500 kWh per year. (Some delta’s are as high as 1000 kWh – 1400 kWh -> 400 kWh)
  • 500 kWh @ an average energy cost of $.35 kWh that’s a $175 savings per year.
  • You can get a new garage fridge for less that $500 -> less than 3-year payback.
• Here are some resources:
  • http://www.kouba-cavallo.com/refmods.htm
Pool Pumps

• Pool pumps are one of the top energy users in residential homes.
• A pool pump can use on average between 30% and 70% of your baseline.
• The “Law of Affinity” states that when you pump water at ½ the speed you use 1/8th the energy.
• Story Time: $200 per month.
• If you have a variable speed pump, re-program it...if you don’t, get one and run it right.
• ½ the speed, double the run time = Same Water Changes Per Day
Water Heating

- Gas water heating is relatively cost-effective, electric water heating is not.
- If you have an electric water heater and it needs replacement consider a heat pump water heater.
- Make sure your pipes are insulated within 6’ of the unit
- Make sure you don’t have a recirculation pump running when not needed.
Misc.

• Fish tanks...
• Exterior lighting...
• Koi ponds / fountains...
• Kilns / shop equipment...
• Dehumidifier...
• Medical equipment...
Seasonal
• The most important area to insulate is the attic. Why?
  • In the winter, hot air rises
  • In the summer, the attic can get to a temperature above 150 Degrees

• Do you clean out your attic first? ($1.00 - $1.50 per sqft)
  • If it’s old
  • If you want to properly air seal

• What type of insulation?
  • Fiberglass, cellulose or spray foam? Why no spray foam?
  • Batt or blown-in?
  • R-Value – R-38 – R-50 ($1.00 - $1.50 per sqft)

• What other work?
  • Platform, lighting, speaking, wiring?
Wall and Floor Insulation

Wall Insulation
- How to test – 1978?
- Typically the 3\textsuperscript{rd} most important, I rank it as the 2\textsuperscript{nd} here in San Diego
- Only insulate your walls if you have air conditioning
- Only insulate your walls from the inside
- Use a thermal camera

Floor Insulation
- Air seal before you insulate
- Only insulate your floor if you want it to be warmer in the winter and if you have AC
- Only use batts and secure them or spray foam
Cathedral Ceiling Insulation

• Usually challenging and expensive... ($3 - $5 per sqft)

• Above or below?
  • Above = Ridgid Foam
  • Below = Blown In or Ridgid Foam

• Ventilation above the roof line or substantial interior ventilation ...breathability...
Air Sealing*

- Cost ($0.50 per sq ft)
- Top plates
- Can lights
  - Can Cover It
- All Penetrations
- Chases
Windows

• Which forms of heat transfer do windows address?

• What are the key energy features of windows?
  • # of Panes
  • # of Low-E Coating
  • Foam in the frame (Type of frame)

• What are the key specs for windows?
  • U-Value
  • SHGC (Solar Heat Gain Coefficient)

• Not usually the most-cost effective upgrade, but they definitely make a big difference! (Cost - $10,000 - $20,000)
Solutions - Seasonal

High Performance Envelope Result

Upgrades
- R-55 Attic Insulation
- Air sealing
- Radiant barrier
- New windows

No Air Conditioning

Outside = 109 Degrees
Inside = 79 Degrees
Solutions - Seasonal

Combustion Safety

- Building Performance Institute Audit ($500)
  - Building Analyst Professional Standards
- Combustion Safety
  - Gas Leaks
  - Worst Case Depressurization
    - Water Heater
      - Draft
      - CO
      - Pressure
  - Furnace
    - CO
    - Pressure
Building Airflow Standard

- Does your family have enough air to breath?
- We’ll talk about how to address this in the ventilation section of this session.

Minimum Building Airflow Standard Example Calculation (ASHRAE 62-89)

**BUILDING DATA**
- Living Space Area = 1500 sqft
- Basement Area = 700 sqft
- # of Occupants = 4
- # of Stories Above Grade = 2
- Location = Albany, NY

**Step 1:** Calculate the Ventilation Required for the Building

\[
\text{AIRFLOW}(b) = 0.35 \times \text{volume} / 60 \times \text{volume} = \\
8 \times (1500 + 700) = 17600 \text{ cubic feet} \\
\text{AIRFLOW}(b) = 0.35 \times 17600 / 60 = 102 \text{ cfm}
\]

**Step 2:** Calculate the Ventilation Required for the People

\[
\text{AIRFLOW}(p) = 15 \times \text{occupants} \\
\text{AIRFLOW}(p) = 15 \times 4 = 60 \text{ cfm}
\]

**Step 3:** Using the Higher Airflow Requirement, Convert to CFM50

\[
\text{MINIMUM CFM50} = \text{AIRFLOW} \times N \times \text{CFM50}
\]

\[
\text{MINIMUM CFM50} = 102 \times 15.4 = 1570 \text{ CFM50}
\]
Continuous Ventilation

- Exhaust Ventilation
- Supply Ventilation
- Heat Recovery Ventilator
- / Energy Recovery Ventilator (HRV / ERV)
Whole House Fan*

- Radiant heat...
- Square footage of home calculations (Air Changes Per House)
- Benefits...
  - $(TOU)$
- Noise / type to install?
- Where to install?
- How to operate?
- Cost = $1,000 - $3,000
- Do you have enough ventilation?
- Peak TOU Off-Set
How it works?

• Boxes
  • Blower
  • Furnace
  • Air Conditioner
• Ducting
  • Return
  • Supply
• Combustion
  • Intake
  • Exhaust
Ducting

- #1 HVAC Upgrade
- Removal – Asbestos?
- Leakage – Duct blaster
- Insulation
- Configuration (No Zones)
  - Return size
  - Return height (Bathtub / Tea Analogy)
  - Return locations
  - Returns relationship to supplies
- Cost = $2,000 - $4,000 New - $500 Reconfiguration
- Health and air quality...
Ducting - Examples
Solutions - Seasonal

Ducting - Examples
Furnace

- Location?
  - Hall closet?
  - Garage?
  - Attic?
- Size? Don’t oversize or else....
- #1 Blower Motor – Variable Speed
- #2 Direct (Sealed) Combustion vs. Induction
- #3 Multiple Stage
- AFUE = > 95% is great!
- Cost = ($3,500 - $7,000)
Air Conditioning

- Tons? / Size?
- High returns?
- Coil
- SEER
- Multiple Stage
- Cost = ($3,000 - $6,000)
Solutions - Seasonal

Fuel Switching

• Heat pump
  • Variable speed blower
  • SEER
  • Strip Heat
  • Cost (New with Ducting) = ($10,000 - $15,000)

• Mini-Split Heat Pump
  • Benefits / drawbacks
  • Applications
  • Cost = ($2,500 - $4,000 per room)
Water Heating

- Solar Water Heating...My perspective is this is 1980
- Heat pumps with solar are ideal these days
- Tank-less are not on Demand – Why tankless?
- Don’t go with an electric tankless...unless you have a lot of power.
- Recirculation pumps save water, usually not energy
  - Care when retrofitting
- Expansion Tank
- $1,000 - $4,000
Roof Ventilation

- Types of Ventilation
  - Birdholes / Soffit, Dormers, Gable Vents, O’Hagin, Whirly Birds
- Quantity of Ventilation – 1 Net Sqft / 150 or 1 Net Sqft / 300
- Location of Ventilation – High and low
- Ridge vents
- Attic fans / Roof fans (Air Seal!)
- Cost = $500 - $1,000

Solutions - Seasonal
Solutions - Seasonal

Roof Ventilation – Examples
Radiant Barrier

- 20 Degrees + Reduction in Attic Temperature
- Retrofit
- OSB Radiant
- Low-E Therma Sheet
- Cost = $1 per square foot
Roofing Material

• Cool Roof
  • Cool shingles
  • Metal roofing
  • Tile roofing
  • Roof colors
Vision:
What is the future vision for the home’s energy systems?
What will change with your home?

Vision

Consumption
- People
- Home
- Usage

Loads
- Low-Hanging Fruit
- Future Solutions
- Long-Term Plan
What will change with your home?

- Will you adding or subtracting people from your home?
- Will you be using more or less energy?
- Will your completing an addition? Removing an old jacuzzi?
- Are you going to do the efficiency measures?
- Are you adding an EV?
Summary:

What are the key highlights from this course that will empower the design great home energy projects?
Why does less energy = better positioned for solar?

• Less energy means a smaller systems size which can mean...
  • Lower investment,
  • Better roof orientations for production,
  • Better roof location for aesthetics,
  • Less requirement to use a high-efficiency panels (more $ panel),
  • More space for future system add-ons,
  • Less roof penetrations,
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  • A smaller energy storage system required,
  • More protection against rate changes...
Key Concepts from the Course

1. Value – Apply Home Performance to Created A High-Value Transaction
2. Impact – Understand and Position Your Project for the Greatest Impact
3. Principals – Grasp the Theory and Think About the Project Dynamically
4. Approach – See the Big Picture but Break the Problem Down In Small Bites
5. Solutions – Have a Strong Sense of the Best Possibilities and Opportunities
6. Vision – See the Home That You are Creating and How it Will Use Energy