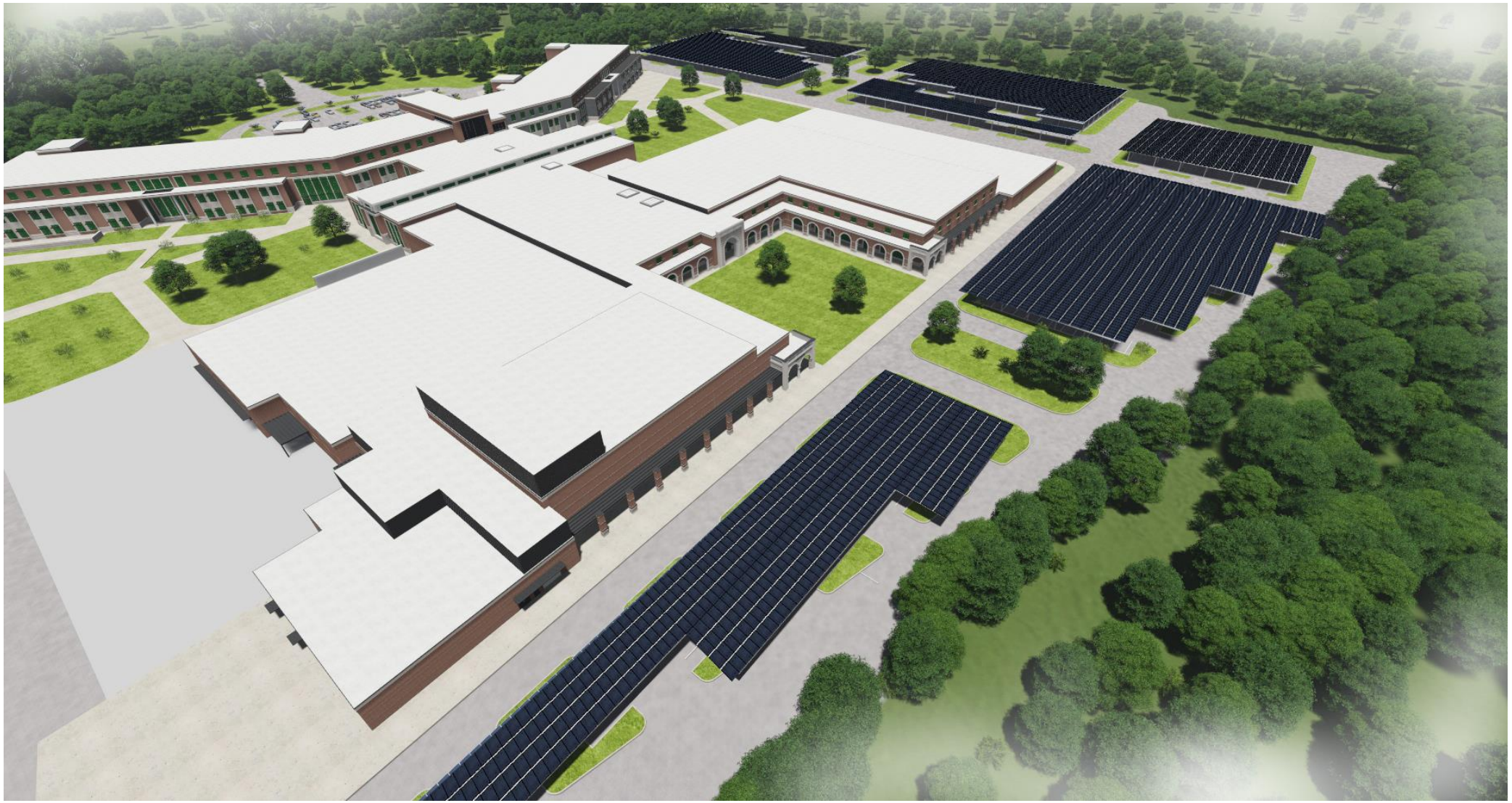
Photovoltaic Design

…Solar Powered High Schools

Grand Lakes HS Rendering with PV Panel Covered Parking…



First of All: What is Net Zero Design*

- A concept of energy self-sufficiency to create a building that does NOT consume more energy than it produces or is available from renewable resources. Equation 1:

  (ENERGY CONSUMED) – (NET ENERGY OBTAINED FROM NON-RENEWABLE SOURCES) = 0

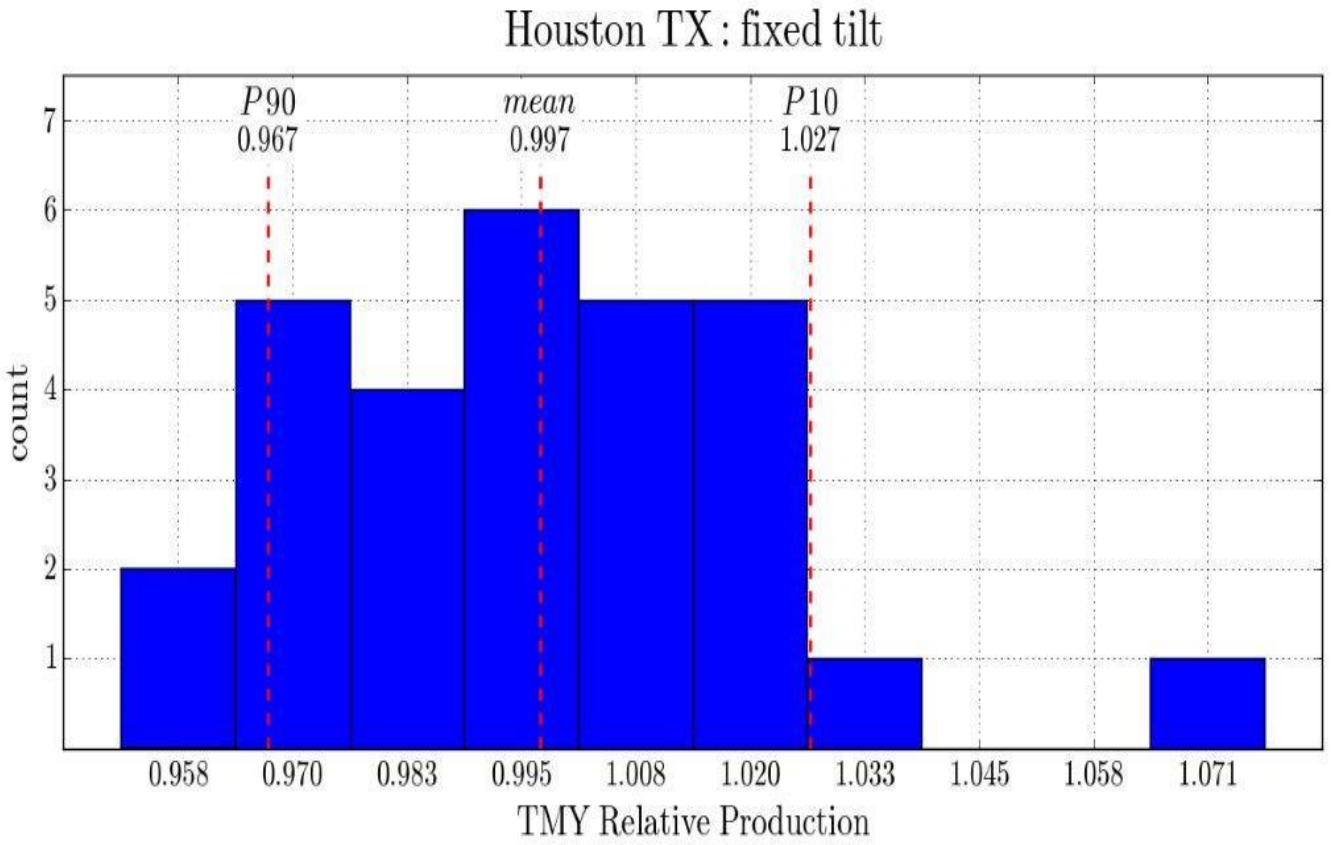
- Based on minimizing energy demand
- Use of local renewable energy resources
- Combines cost-effective energy measures (e.g.)
  - Solar photovoltaics (PV)
  - Solar water heating
  - Landfill gas
  - Wind Power

* Contributing Source: National Renewable Energy Laboratory (NREL)

Building Blocks of Photovoltaic Systems

- A Typical Solar Panel Produces 330 watts direct current (DC)
- Multiple Solar Panels Are Connected Together in Larger Groupings Called Arrays
- Arrays Are Connected To The Power Distribution System Through Inverters (direct current to alternating current or DC to AC)
- Inverters Provide Power To The Building Loads Or Back To The Utility Grid

Energy Production Analysis: Photovoltaic (PV) Energy Systems



- Individual longitude and latitude provides various solar power capabilities (*pvwatts program*/NREL)
- 4-6 hours of usable daily sun-hours is average range throughout the year in Texas
- Analyze the PV location to determine the predicted power output
- Summary of total building load in kilowatt-hours needed through energy model or historical data

TMY = Typical Meteorological Year (Source NREL)

Step 1 – System Sizing

- Calculate Annual Consumption kWh
- Utilize Solar Analysis to determine production constant for project site
- Determine % Shift (60% - 70% max. recommended, no real benefit to overproduce)
- Junior High School Example: 2,104,000 kWh with a constant of solar design for Houston of 1,300 = 1.6 mW for 100% island
- 60%-70% offset yields 1 mW P-V System

Step 2 – Site Controls

Review Available Space Allocation For Solar Array

- Ground/Pedestal Mounted Requires Raw Land

  1 mW (mega-watt) of solar array requires 4-5 acres

- Roof Mounted Requires Extended Available Roof Area

  1 mW (mega-watt) of solar array requires 130,000 square feet of roof area

- Canopy Mounted Is Utilized With Covered Parking Structures

  1 mW (mega-watt) of solar array equates to 240 covered parking spaces

Step 2– Site Controls

Step 2 – Site Controls

Example Project Parameters:

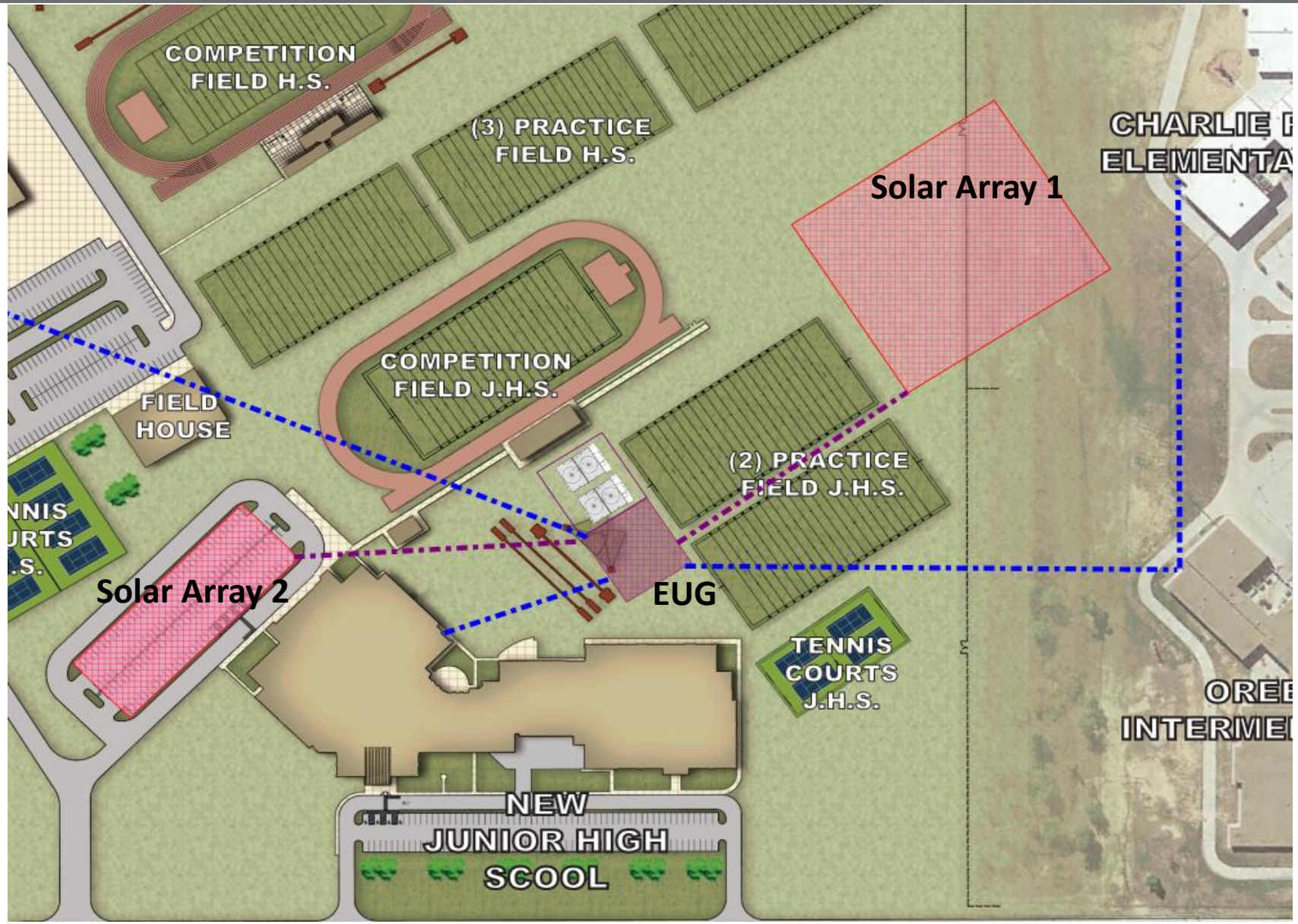
- Proposed New 225,000 sq.ft. Junior High School

- 5 Acre P-V Ground Mounted Solar Array 1

- 144 Parking Space Canopy Mounted Solar Array 2

- Electric Utility Grid Interconnect and P-V Switchgear Building (EUG)

- Underground DC and AC Feeders



Step 3 – Utility Interconnection/Distribution Design

- Obtain Utility Agreement
- Consult an Attorney and Read the Fine Print Prior To Execution
- Include Utility Company in Conceptual Planning: Determine Substation Suitability
- Ensure Engineering One-Line Diagram Includes Utility Safety Relaying and Disconnecting Means
- Design for Parallel Operation & Net Metering

ATTACHMENT A

AGREEMENT FOR
INTERCONNECTION AND PARALLEL OPERATION OF DISTRIBUTED GENERATION

This Interconnection Agreement ("Agreement") is made and entered into this _____ day of _____, 20__, by Entergy Gulf States, Inc - Texas, ("Company"), and _____ ("Customer"), a _____ [specify whether corporation, and if so name state, municipal corporation, cooperative corporation, or other], each hereinafter sometimes referred to individually as "Party" or both referred to collectively as the "Parties". In consideration of the mutual covenants set forth herein, the Parties agree as follows:

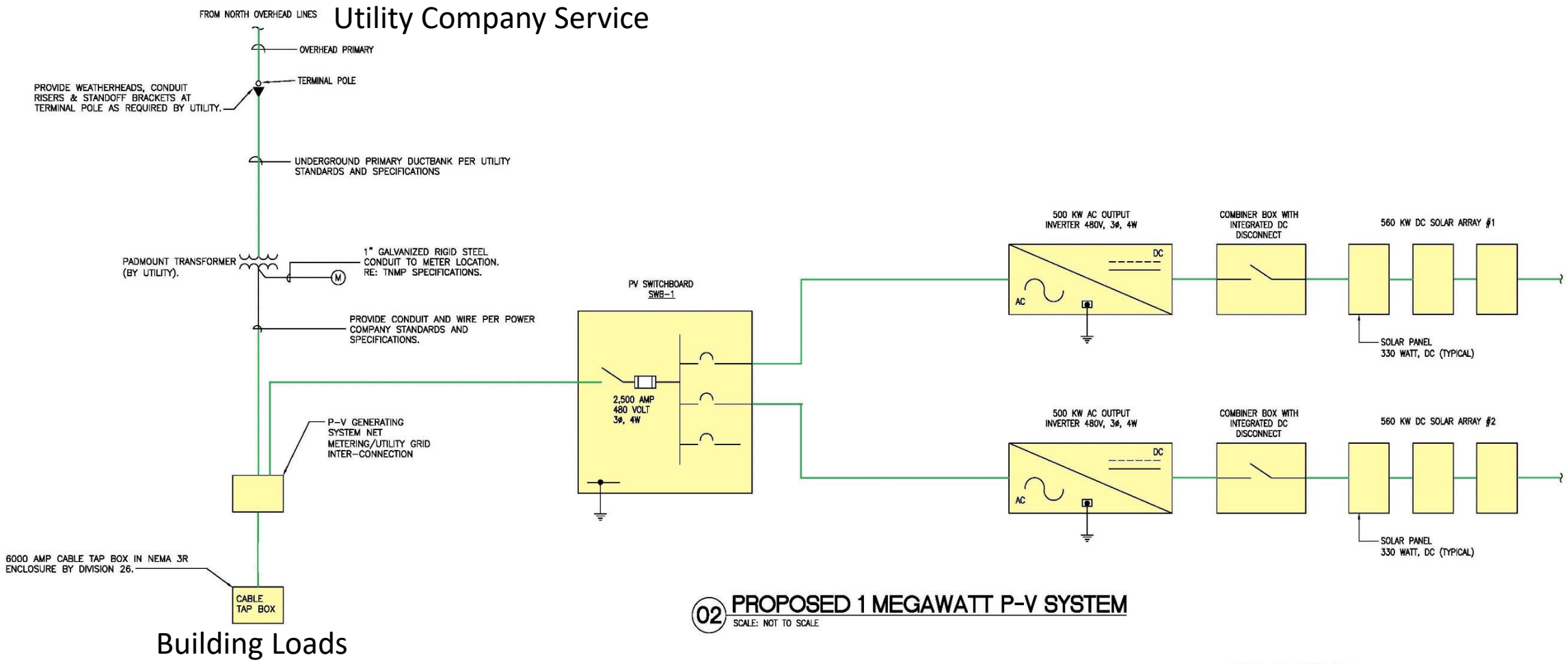
1. **Scope of Agreement –** This Agreement is applicable to conditions under which the Company and the Customer agree that one or more generating facility or facilities of ten MW or less to be interconnected at 60 kV or less ("Facility or Facilities") may be interconnected to the Company's utility system, as described in Exhibit A.

2. **Establishment of Point(s) of Interconnection –** Company and Customer agree to interconnect their Facility or Facilities at the locations specified in this Agreement, in accordance with Public Utility Commission of Texas Substantive Rules § 25.211 relating to Interconnection of Distributed Generation and § 25.212 relating to Technical requirements for Interconnection and Parallel Operation of On-Site Distributed Generation, (16 Texas Administrative Code §25.211 and §25.212) (the "Rules") or any successor rule addressing distributed generation and as described in the attached Exhibit A (the "Point(s) of Interconnection").

3. **Responsibilities of Company and Customer –** Each Party will, at its own cost and expense, operate, maintain, repair, and inspect, and shall be fully responsible for, Facility or

Step 3 – Utility Interconnection/Distribution Design

- Develop 1-Line Electrical Distribution Diagram

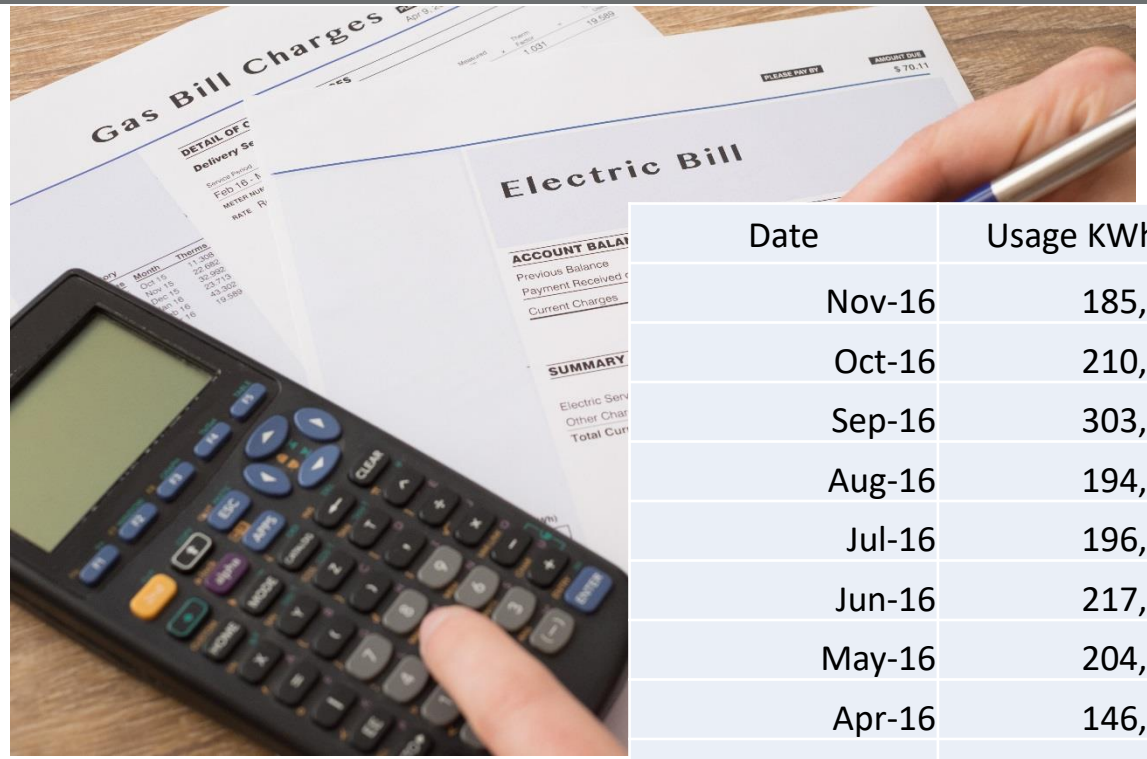


Step 4 - Economic Analysis / Who's Buying the Power?

- Installed Cost (1 mW): $1,700,000*
- Annual Usage Savings: $120,000
- Annual 4 CP***/Demand Savings: $28,500
- Potential Net Metering Recovery**: $38,000
- Annual Maintenance Cost: $8,000
- Net Annual Savings = $178,500
- Simple Payback: 9.5 yrs.

*estimated/pending bid ** pending Entergy approval

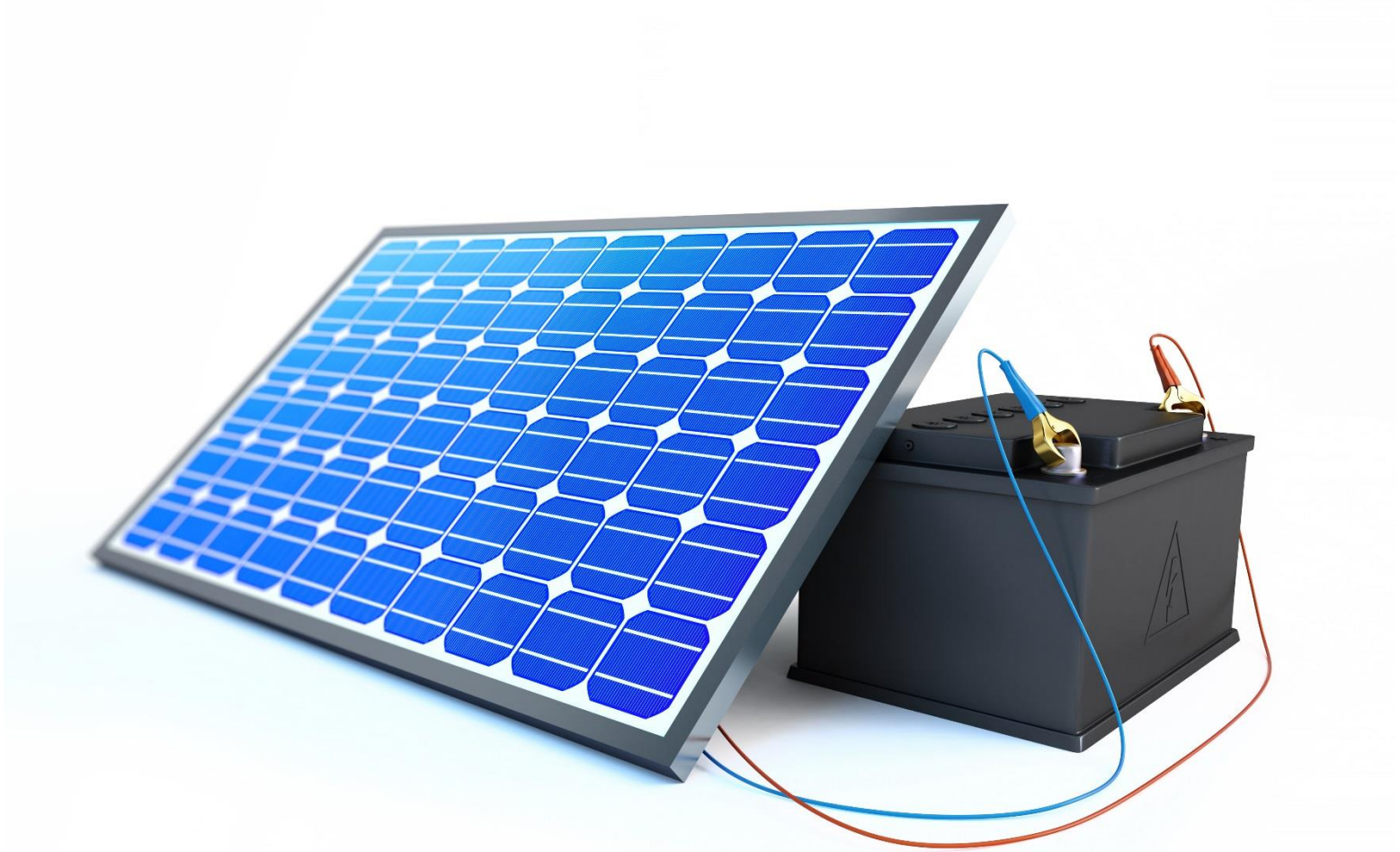
*** 4 CP = Four Coincident Peak



Date	Usage KWh	Demand KW	Total Bill
Nov-16	185,500	840	$17,694.26
Oct-16	210,500	970	$18,089.75
Sep-16	303,500	1075	$23,645.17
Aug-16	194,500	1265	$17,313.22
Jul-16	196,500	1020	$15,747.52
Jun-16	217,000	1160	$19,833.59
May-16	204,000	865	$17,115.58
Apr-16	146,000	765	$13,204.52
Mar-16	132,500	720	$12,160.70
Feb-16	153,000	610	$13,169.35
Jan-16	117,500	575	$10,841.57
Dec-15	142,000	745	$13,469.14
Nov-15	168,000	850	$15,719.95
Oct-15	186,500	810	$16,631.44
Sep-15	246,500	875	$20,669.53
Annual bill summary:	2,104,000 kWh		$185,876

Should I Include A Battery System With My Solar Array?

- Why Use Batteries
  - Solar is unpredictable
- Technology
  - Lithium Ion
- Demand Response
- Peak kVA/4CP Avoidance
- Battery Cost?



Different Options to Pay for Solar Projects

- Procurement & Payment Options
  - Power Purchase Agreement
  - Design-Build Performance Specification with Power Output Guarantee over time
  - Add Alternate Bid to New Construction Project – Competitive Sealed Proposal
  - Applying for Grants
  - Clean Renewable Energy Bonds
  - Utility Rebates

Additional Considerations

- Net Billing
  - Consult your service provider MP2
  - Entergy
- Net Metering
  - Entergy
  - Centerpoint
  - CPS
- Selling Power Back to the Grid
  - Sales price is not the same as the purchase price

Additional Considerations

- Photo-Voltaic System Maintenance
  - Annual cleaning of solar panels
  - Semi-annual torqueing of DC connections
  - Changing of filters quarterly on DC to AC voltage inverters
  - Costs: $8,000 annually per mW budgetary

Additional Resources

- http://www.nrel.gov
- https://pvwatts.nrel.gov
- http://www.entergy-texas.com/Global/Documents/utility/net_metering_application.pdf

Conclusions / Questions

Thank You!

Questions?