

System Engineering Leadership Program
(SELP)

Systems Engineering Integrative Project
SELP 695/696
Spring 2009

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WINSTON R. DEMMIN

**Implementation of a 500 KV Solar System
For Commercial Use**

OVERVIEW

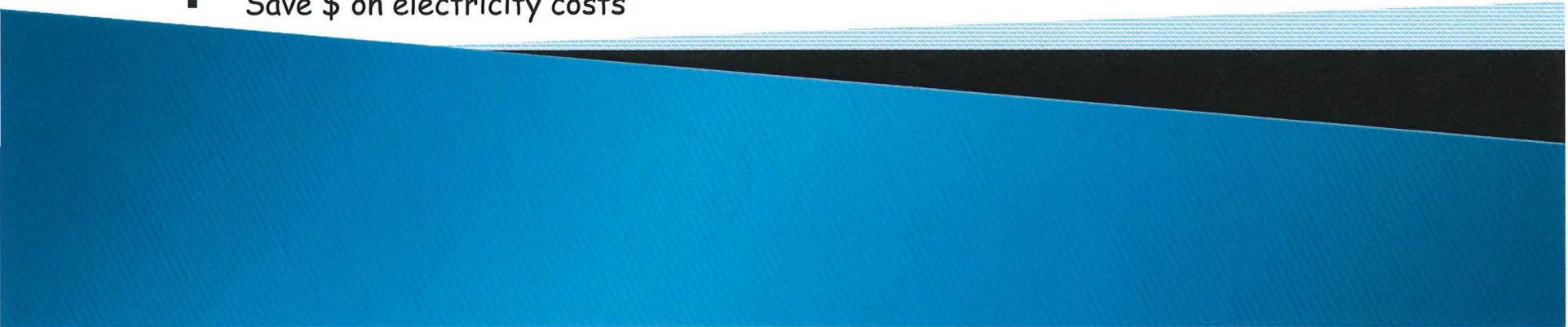
- ☐ Project Scope & Requirements
- ☐ Renewable Energy Options
- ☐ Cost Trends
- ☐ Solar Photovoltaic (PV) Technology
 - Technology Specific Notes
 - Grid Tie System
 - World/ US Solar Output
 - Key Players
- ☐ Benefits and Incentives
- ☐ Solar Availability
- ☐ Financials
 - Energy Cost Comparison
 - Return on Investment (ROI) Projections
- ☐ SE Systems Engineering Tools
- ☐ Pro's & Con's
- ☐ Keys To Project Success
- ☐ Project Highlights To Date
- ☐ Conclusions / Questions

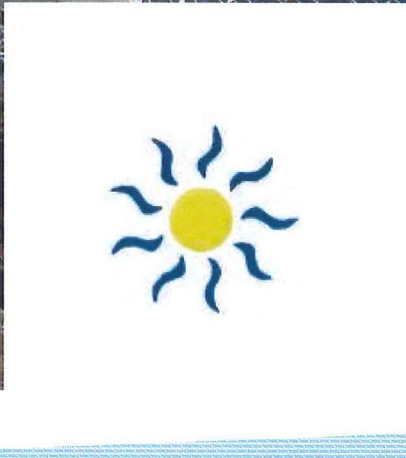
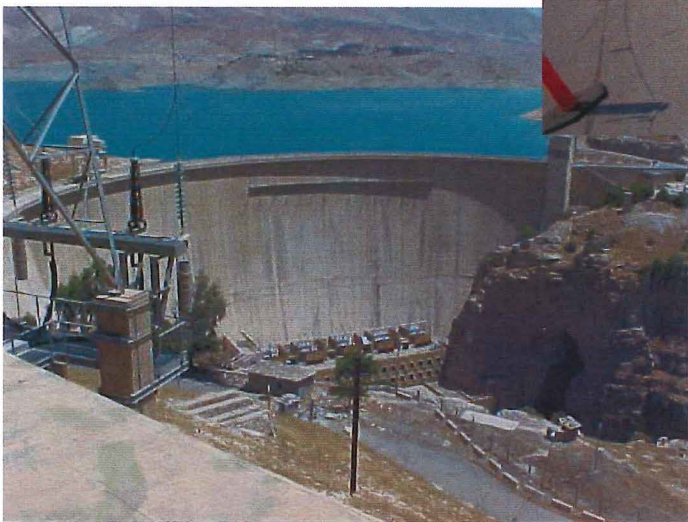
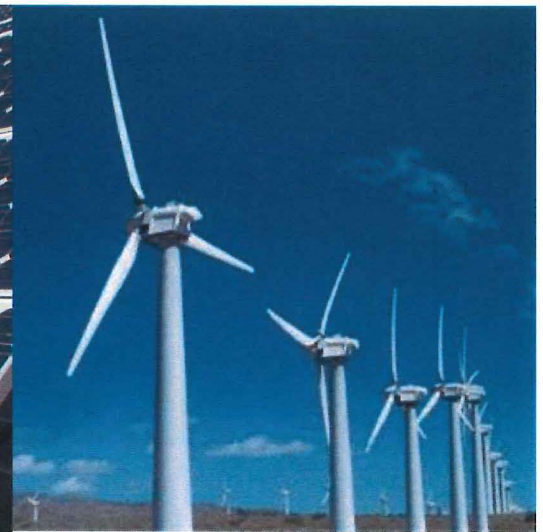
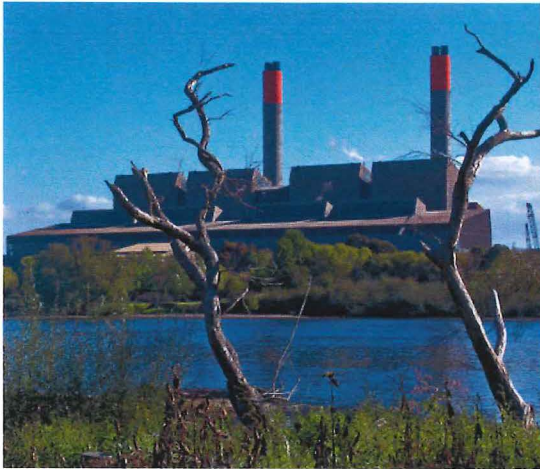


The Project Scope

- Integrate a solar power system as an environmentally "green" commercial project
- Install and monitor Photo Voltaic (PV) Array modules
- Provide critical process analysis, experienced instrument and control systems expertise
- Improve power generation efficiencies, product quality, personnel safety & meet environmental compliance
- Provide substantial cost savings to the CLIENT offering a predictable project and system performance
- Provide effective, predictable and competitive specialty & automation engineering solutions

CLIENT Requirements

- Streamline the implementation of a PV (photovoltaic) array system that will produce DC electricity when exposed to sunlight
 - Capitalize on available state and federal rebates offered for solar projects
 - Reorganize the overall schedule to have task run concurrently
 - Develop a financial model that allow savings to pay for the system over time
 - Minimize alteration of the existing building to facilitate the project
 - Save \$ on electricity costs
- 

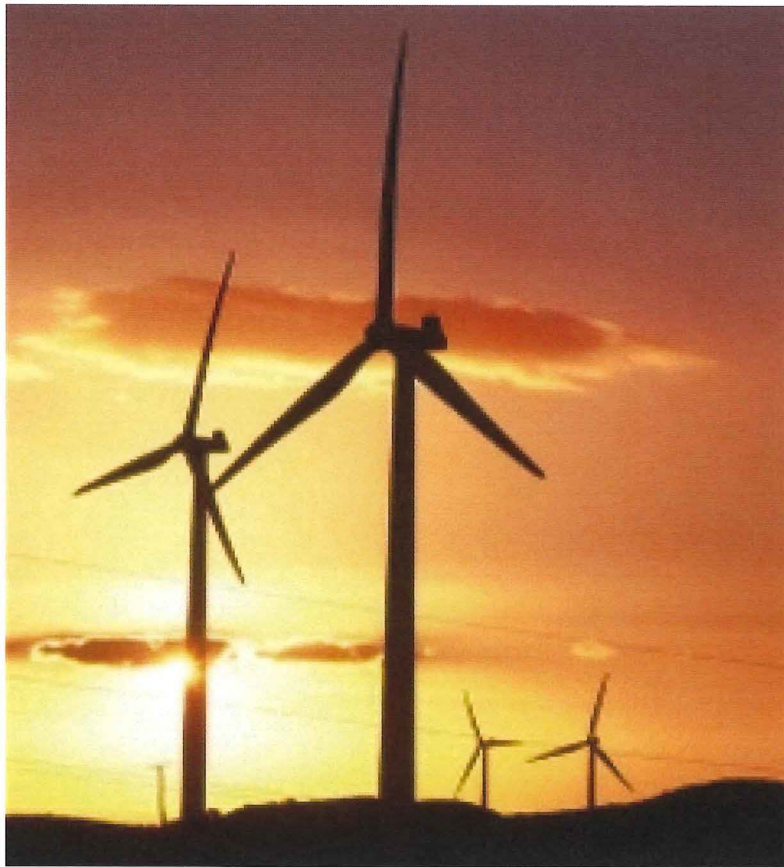


World Power Generation

ANY SUSTAINABLE ENERGY
SOURCE THAT COMES FROM THE
NATURAL ENVIRONMENT



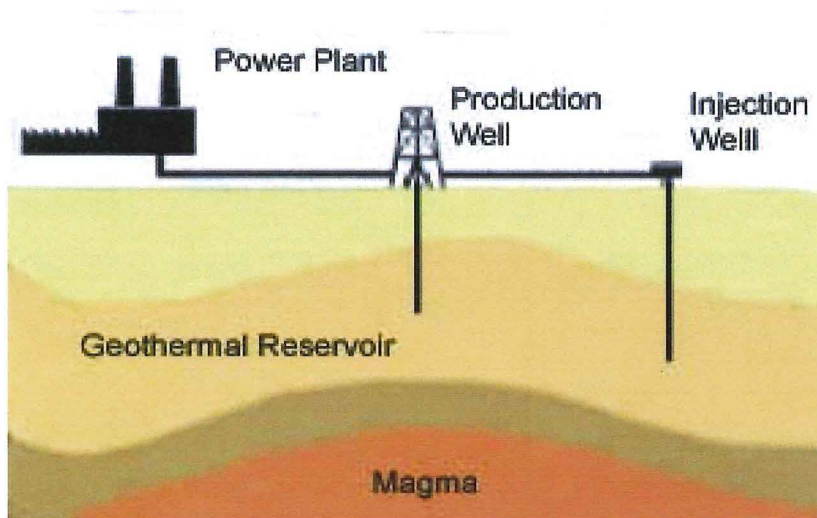
Wind



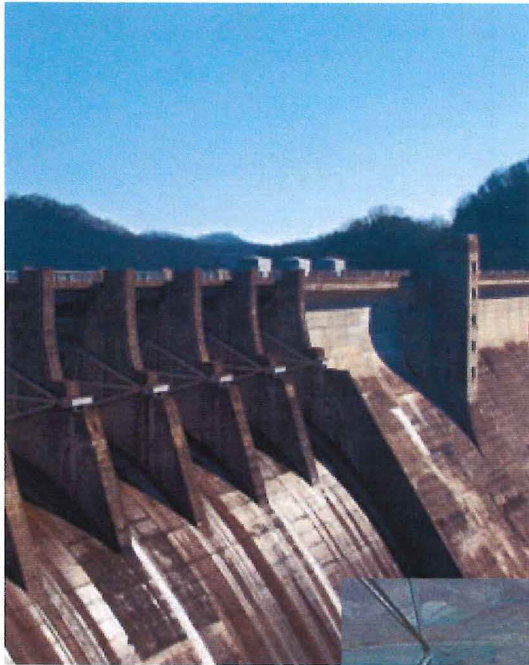
**MECHANICAL ENERGY CONVERTED
TO ELECTRICITY BY WIND
TURBINES**



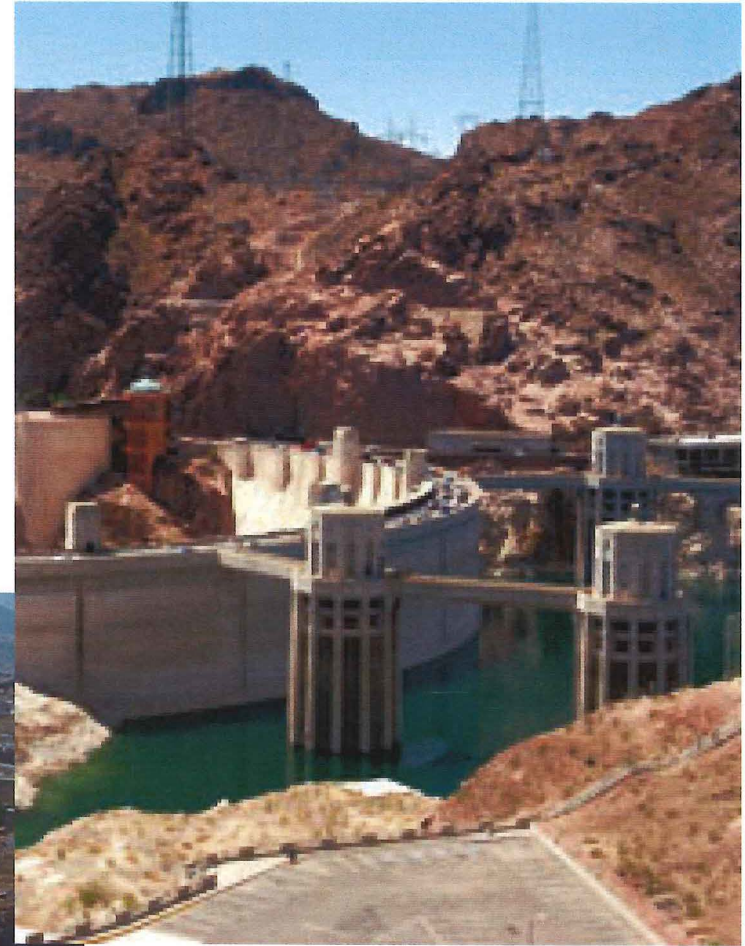
Geothermal



**POWER EXTRACTED FROM HEAT
STORED IN THE EARTH**



Water



**POWER THAT IS DERIVED FROM
THE FORCE OR ENERGY OF MOVING
WATER**



Biomass

Types of Biomass



Wood



Crops



Garbage



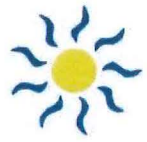
Landfill Gas



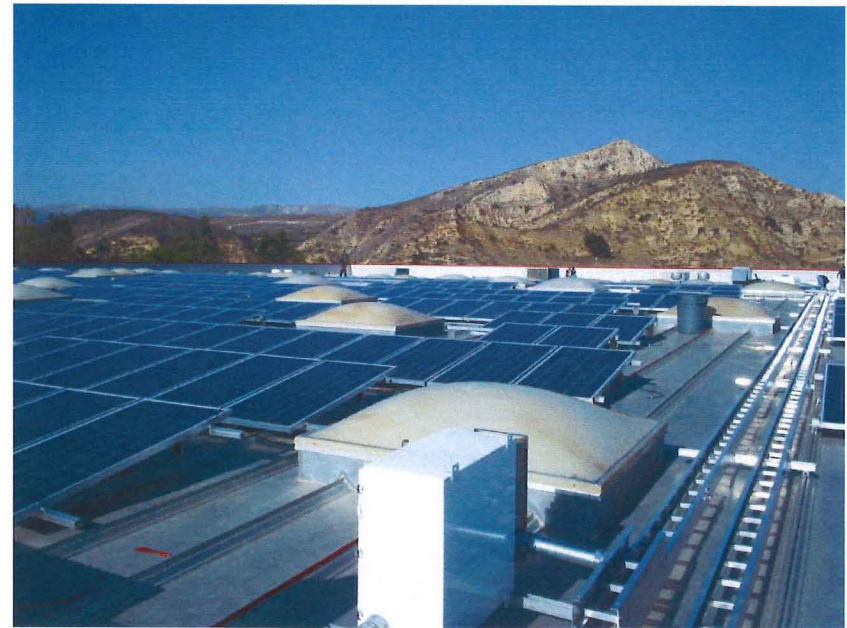
Alcohol Fuels



**LIVING AND RECENTLY DEAD
BIOLOGICAL MATERIAL THAT CAN
BE USED AS FUEL**



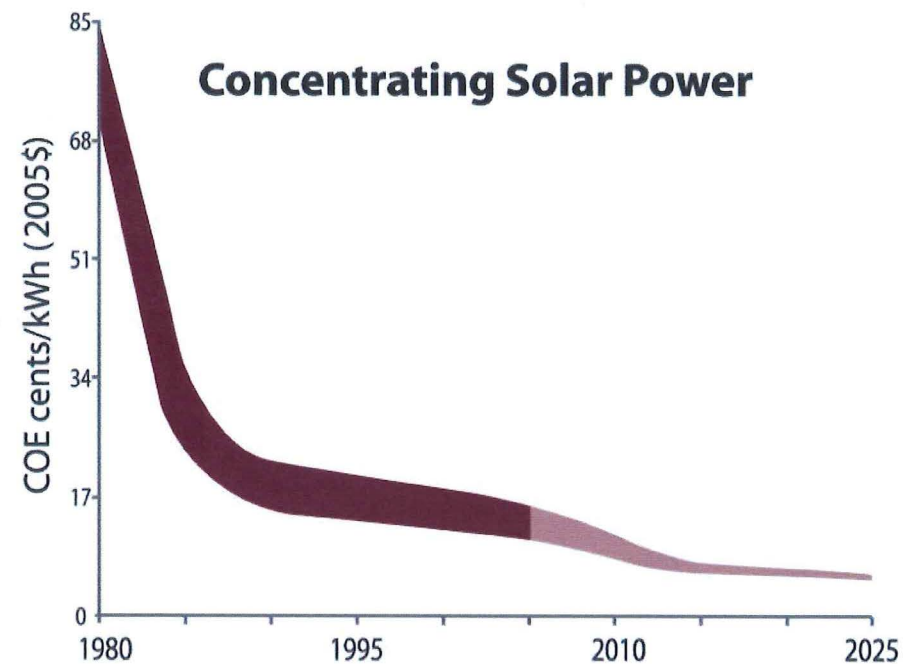
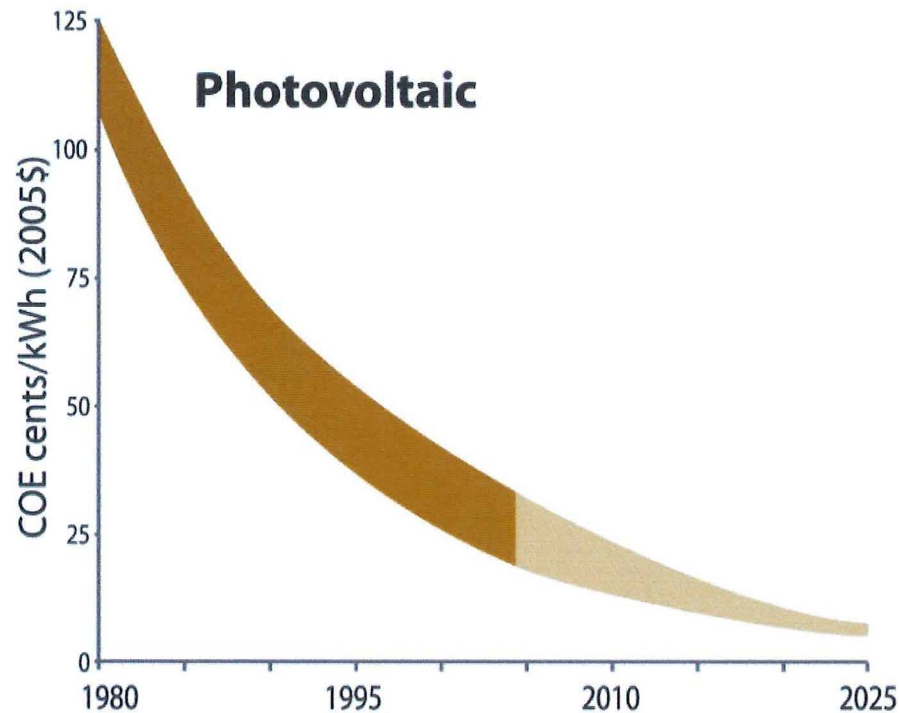
Solar (Photovoltaics)



**A METHOD FOR GENERATING
ELECTRICAL POWER BY USING
SOLAR CELLS IN PV MODULES**

Renewable Energy Cost Trends

Levelized cost of energy in constant 2005 \$¹



NREL Energy Analysis Office

¹These graphs are reflections of historical cost trends NOT precise annual historical data.

Renewable Electricity Technology Cost Trends

Chart Notes

Background

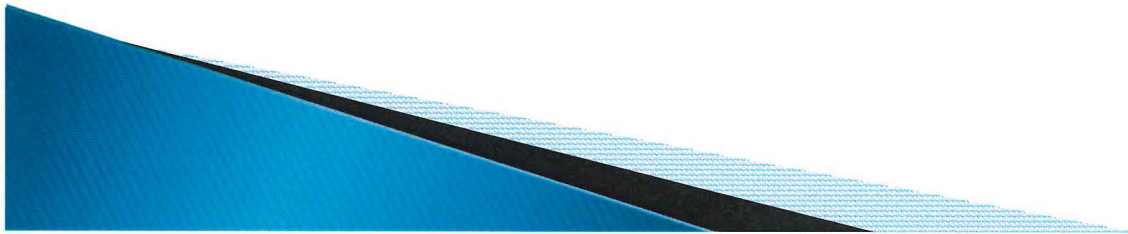
- The Cost Curves are expressed as a band in constant 2005 year dollars
- Actual project costs can vary substantially based on variables such as:
 - Siting
 - Permitting costs
 - Transmission access
 - Labor costs
 - Financing terms
- The Future Cost Curves generally reflect how the DOE Renewable Energy Programs expect the costs of renewable energy to decrease through:
 - lowered technology costs
 - improved performances
 - R&D efforts
- The Cost Curves do not include the effects of tax credits or production tax incentives

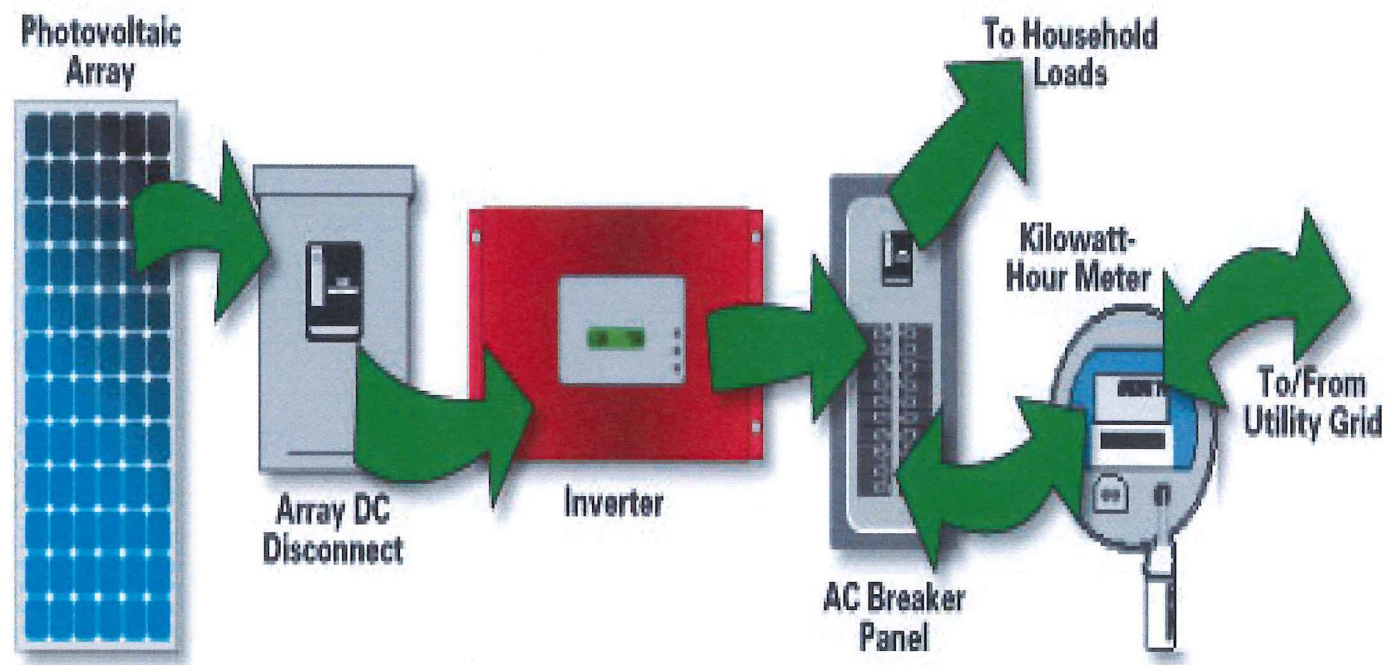


TECHNOLOGY SPECIFIC NOTES

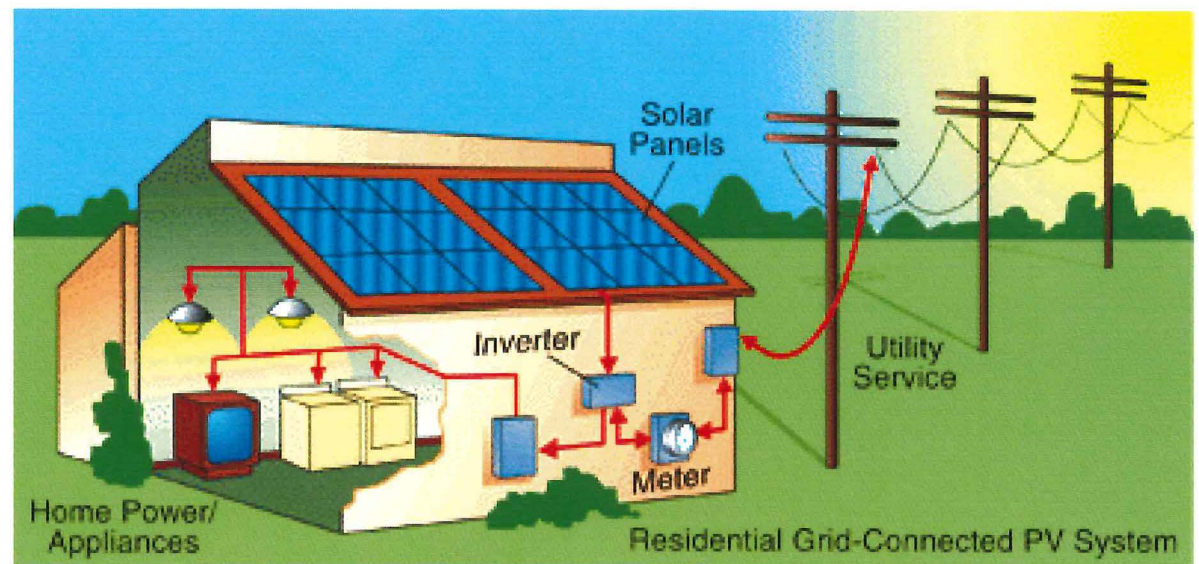
- **Solar**
 - Improved reflectors and lower-cost designs
 - Improved solar thermal receivers
 - Heat exchangers & fluid handling technologies
 - Run turbines and generators

- **Photovoltaic**
 - Increasing penetration of thin-film technology
 - Higher efficiencies
 - Increased reliability (which can reduce module prices)
 - Improved manufacturing processes
 - Lower balance of system costs through technology improvements & volume sales





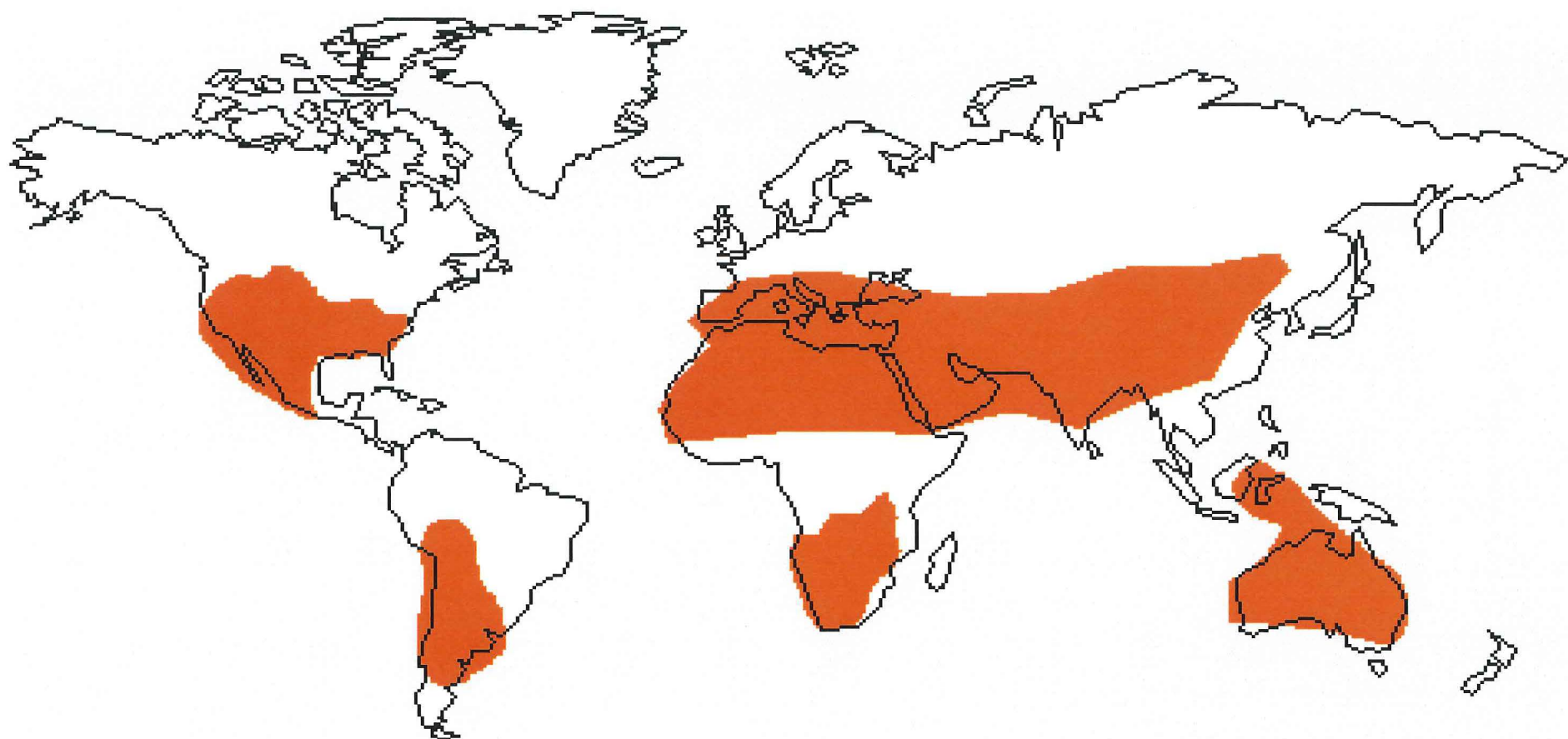
The Basics of Solar Power



THE SIMPLE GRID CONCEPT

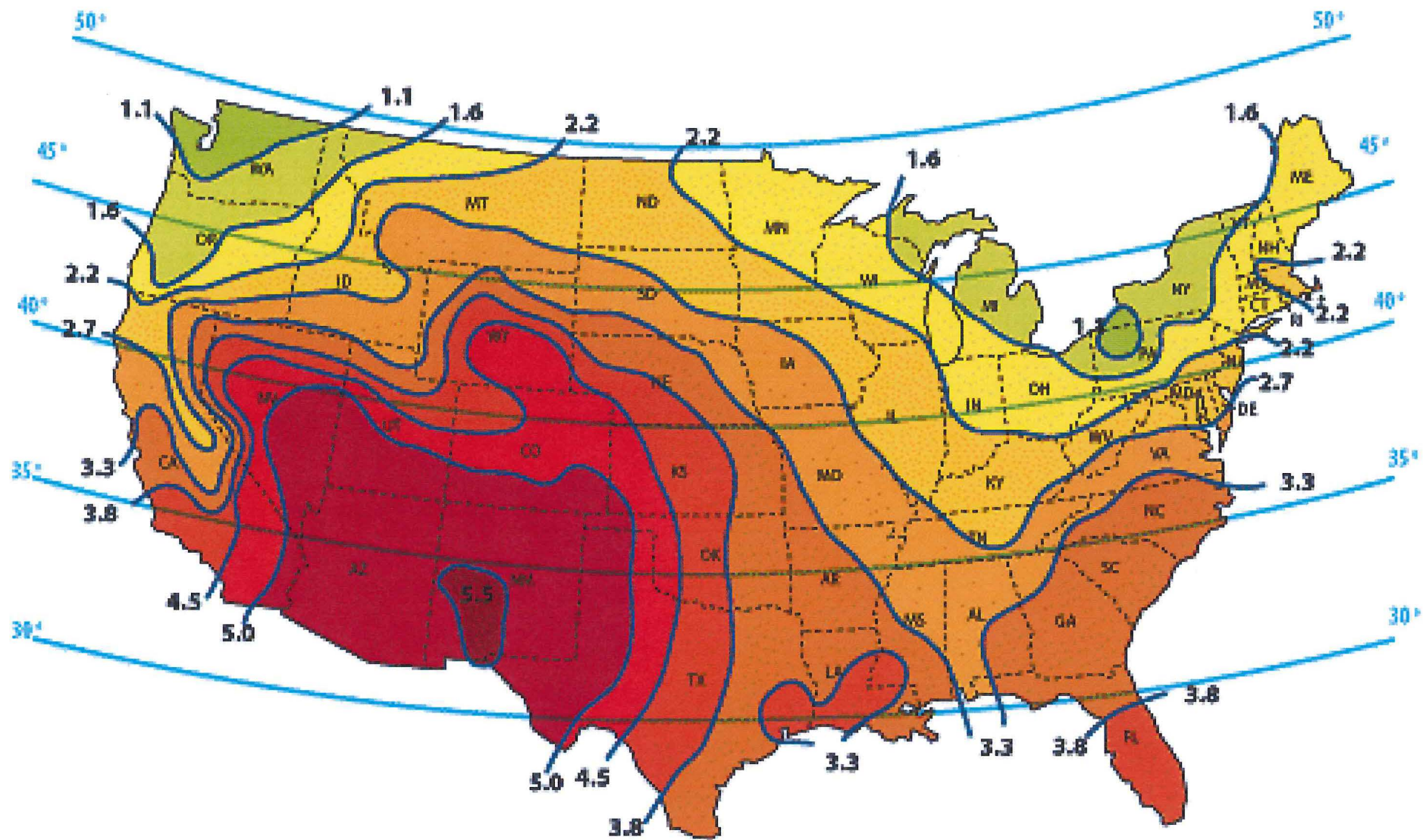


Areas in The World With High Insolation Output

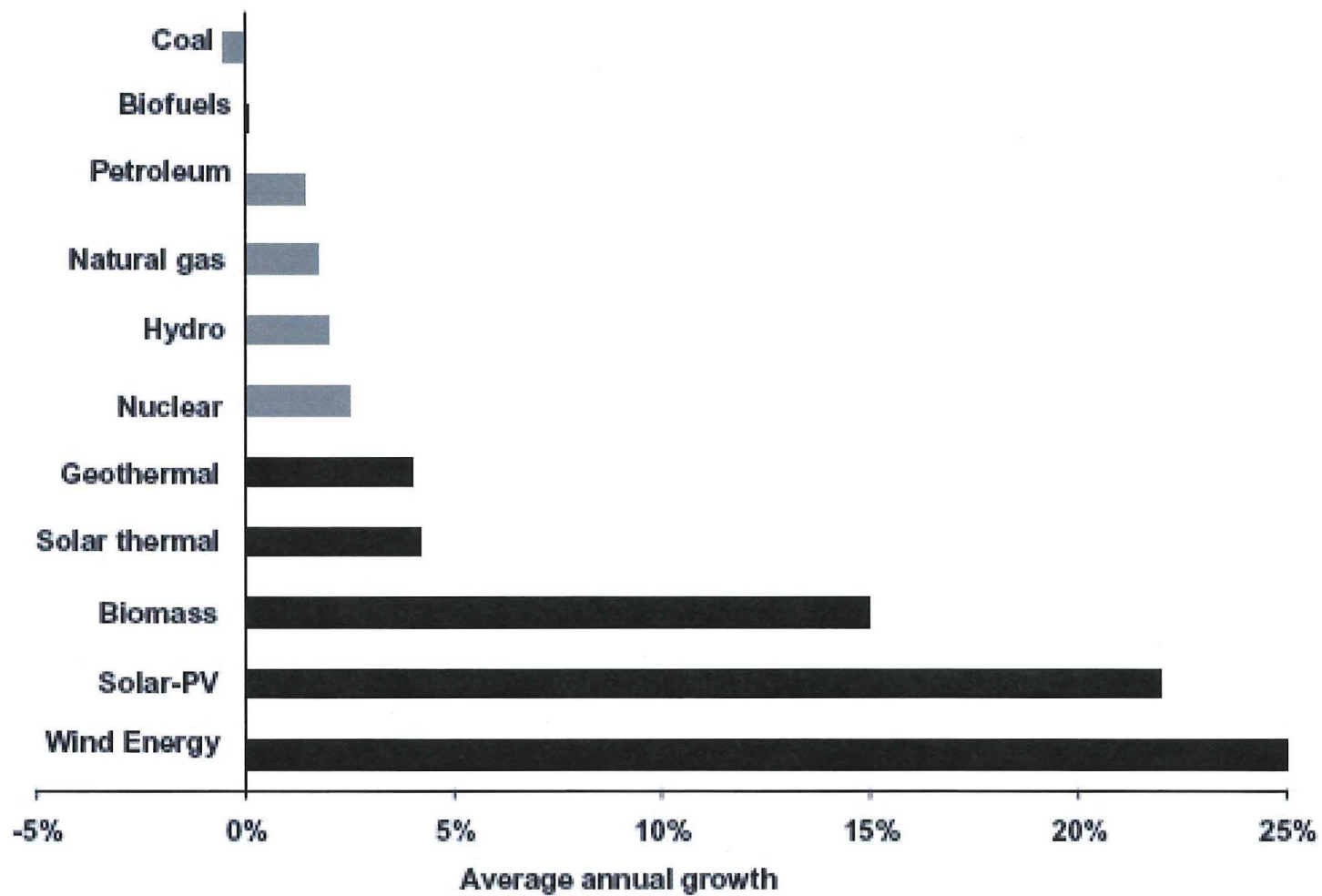


Global Solar Energy Abundance Map

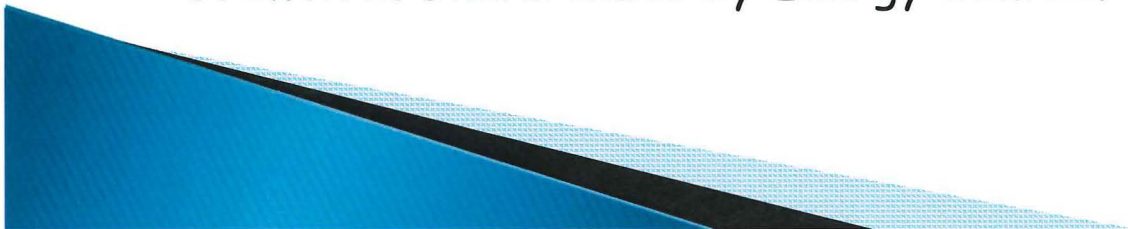




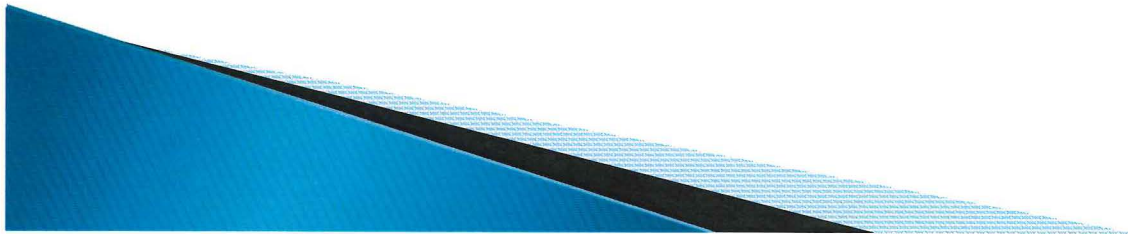
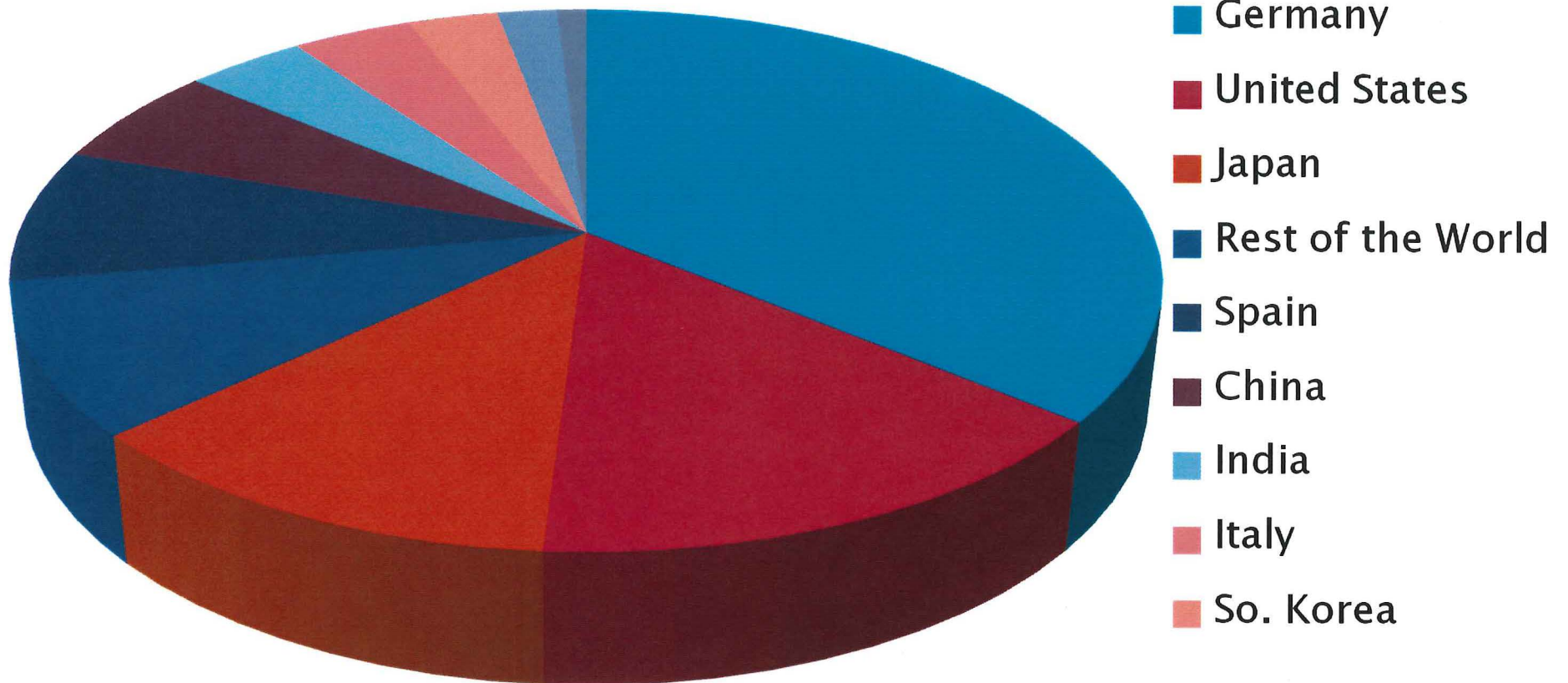
USA PV Solar Radiation Map



Growth in Global Sales by Energy Source.: Courtesy Shell Oil Co.



World Top Ten Solar Markets



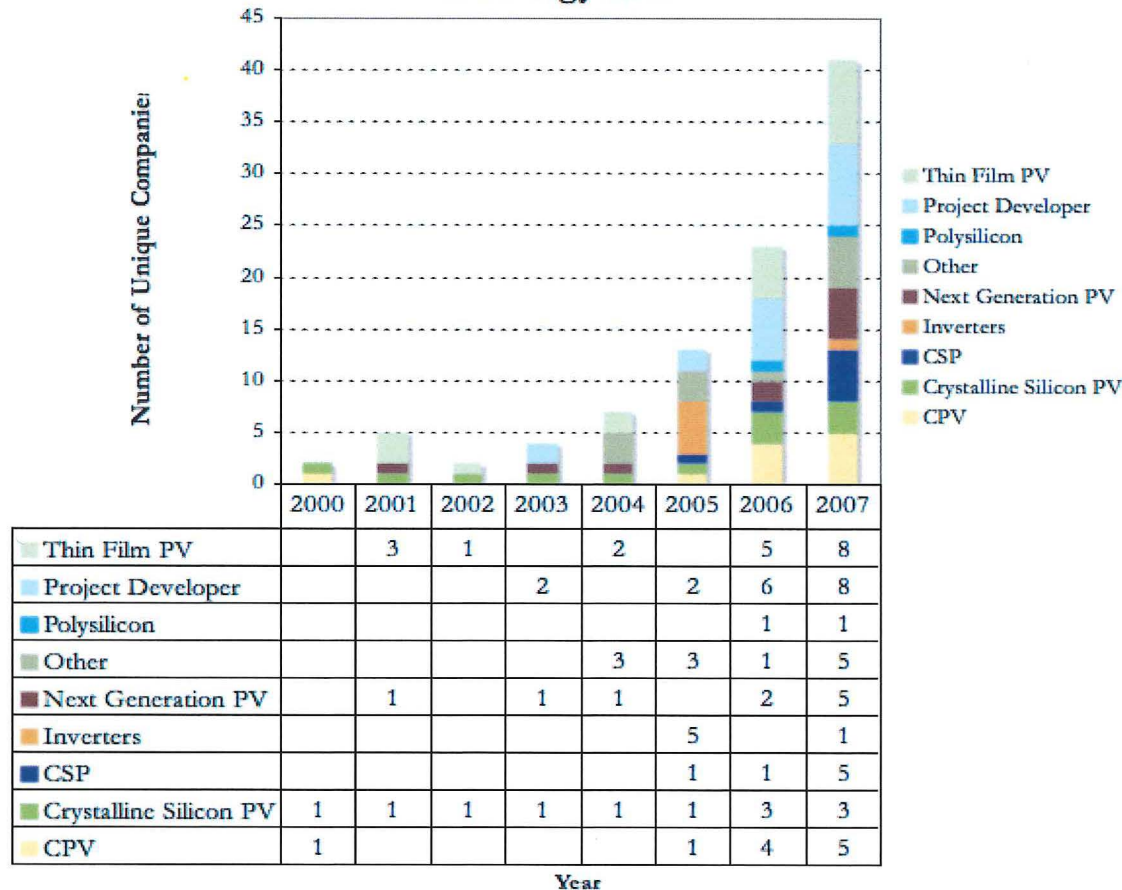


Smart choice for power



U.S. Solar Companies Are Making Significant Cost & Quality Improvements To Their Technologies

Unique US Solar Companies Receiving Private Investment by Technology Area



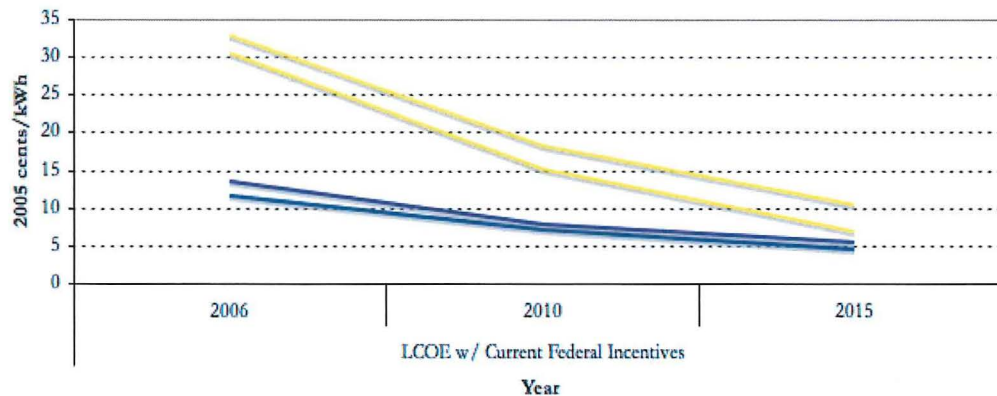
Source: NEF / NREL / FACC

- All of these companies are pursuing 'grid parity' or economic competitiveness
- Many firms calculate 'grid parity' with approximately 10 c/kWh electricity calculated over the life of the solar system
- The point at which photovoltaic electricity is equal to or cheaper than GRID POWER

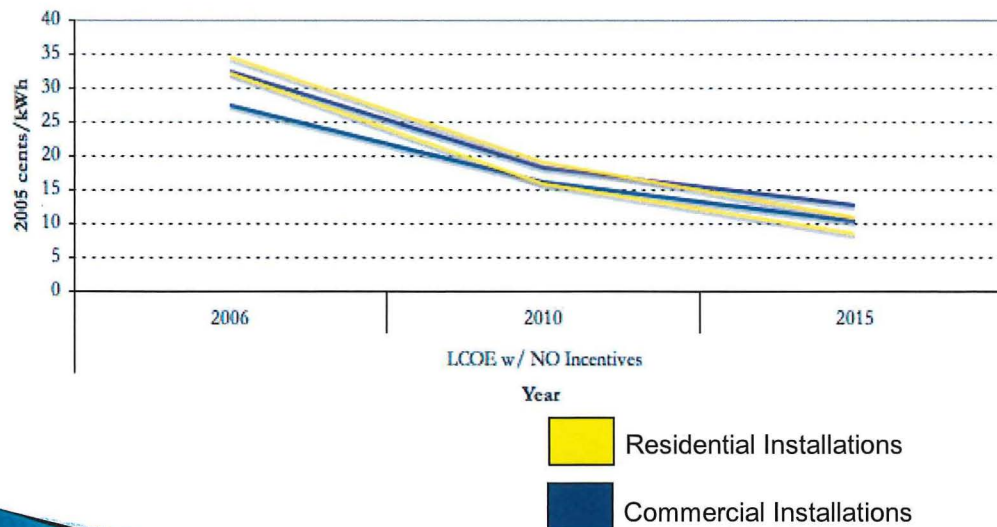
DOE & Many Companies' Investors Believe That Many Of Their Technologies Will Reach 'Grid Parity' By 2015 Or Sooner

Installed System Cost Ranges Have Implications For Levelized Cost of Energy

Levelized Energy Cost with Current Federal Incentives



Levelized Energy Cost with NO Incentives

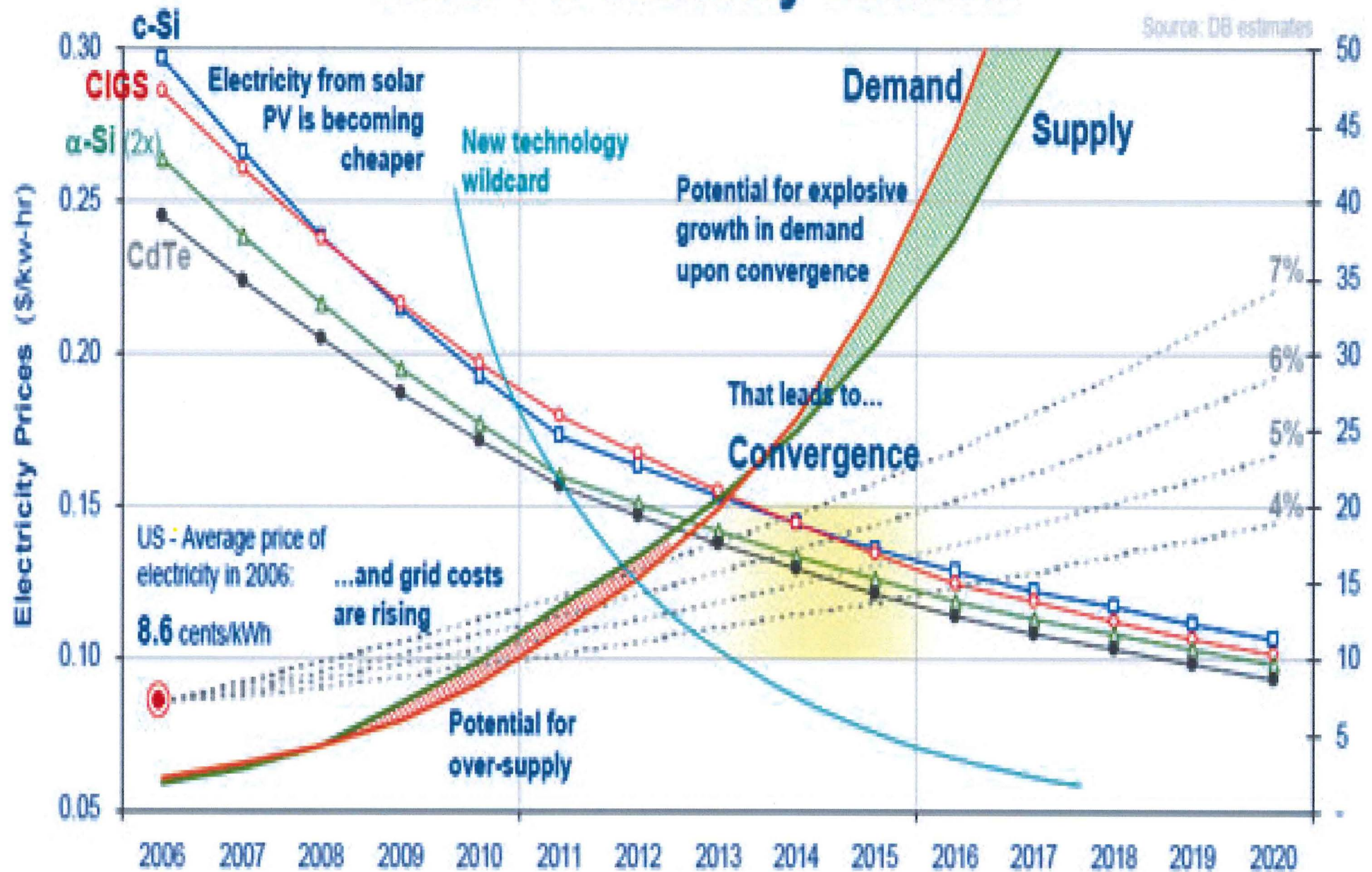


- Commercial / utility scale PV systems are currently economically competitive with grid electricity prices in many areas

- Both residential and commercial systems will be less expensive than grid electricity by 2010, assuming that the 4.7% annual growth rate continues

Solar market penetration is created by the levelized cost of energy (LCOE) over the lifetime of the solar system vs. grid electricity prices and government/utility incentives

Solar PV industry outlook

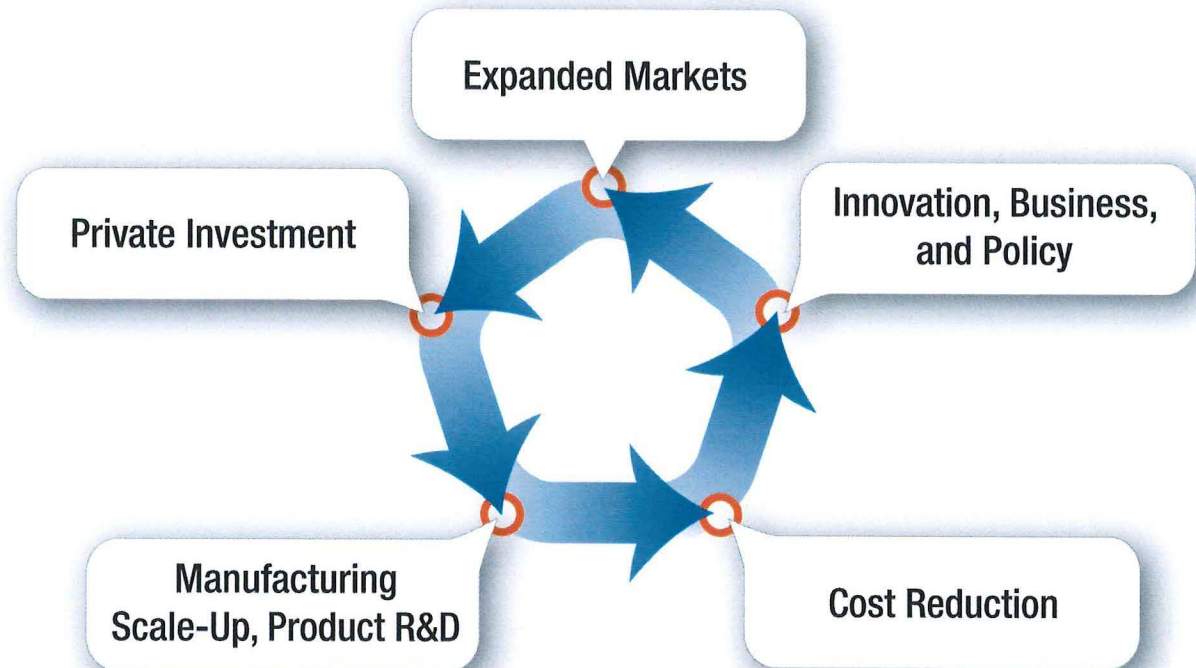


Stephen O'Rourke, SEMI Industry Strategy Symposium

Technology and business innovation stimulates public and private investment, which commences a virtuous cycle of market expansion

- In order to achieve goals; solar investors and companies must execute and perpetuate this cycle
- Policy supports are only in place for a limited duration, and the recent rapid expansion of investment in solar is maximizing the utility of these incentives while they last
- More mature, larger markets emerge from the end of the early market hyper-growth stage

Positive Feedback for PV



In the next years of the SAI, the DOE's Solar Program will focus on achieving price-parity and scale for solar electricity generation from *both PV and CSP*



SAVING ANALYSIS for Electric System – Solar Implementation Project

Purchase Price: **\$3,469,945**

System Size: **498.0 kW AC**

Generation, 1. year: **817,144 kWh**

Assumptions

Installation
Tax Incentives

Jun-08
April each year

Electric Rate
Electric Rate Increase

\$0.30 / kWh
5.0% / year

Year	Electricity Generated	Electricity saved	HI Tax Credit	Fed Tax Credit	Fed Tax Savings Depreciation ¹⁾	Operating Cost ²⁾	Total Savings	Cumulative Savings	NPV @ 6%
2008	408,572	\$122,572				-\$5,037	\$117,534	\$117,534	
2009	815,101	\$256,757	\$1,000,000	\$1,040,984	\$208,482	-\$10,075	\$2,494,128	\$2,611,662	\$7,726,925
2010	811,026	\$268,247			\$330,339	-\$10,377	\$588,209	\$3,199,871	\$5,896,413
2011	806,971	\$280,251			\$198,203	-\$10,688	\$467,766	\$3,667,637	\$5,449,989
2012	802,936	\$292,792			\$118,922	-\$11,009	\$400,705	\$4,068,342	\$5,309,222
2013	798,921	\$305,894			\$118,922	-\$11,339	\$413,477	\$4,481,819	\$5,227,071
2014	794,926	\$319,583			\$59,481	-\$11,679	\$367,385	\$4,849,184	\$5,127,217
2015	790,952	\$333,885				-\$12,030	\$321,855	\$5,171,039	\$5,087,485
2016	786,997	\$348,826				-\$12,390	\$336,435	\$5,507,475	\$5,049,679
2017	783,062	\$364,436				-\$12,762	\$351,674	\$5,859,148	\$5,016,225
2018	779,147	\$380,744				-\$13,145	\$367,599	\$6,226,748	\$4,985,525
2019	775,251	\$397,783				-\$13,539	\$384,243	\$6,610,991	\$4,895,857
2020	771,375	\$415,583				-\$13,946	\$401,638	\$7,012,629	\$4,805,365
2021	767,518	\$434,181				-\$14,368	\$369,553	\$7,382,182	\$4,692,049
2022	763,680	\$453,610				-\$14,795	\$438,816	\$7,820,997	\$4,604,019
2023	759,862	\$473,909				-\$15,239	\$458,671	\$8,279,668	\$4,441,445
2024	756,063	\$495,117				-\$15,696	\$479,421	\$8,759,089	\$4,249,280
2025	752,282	\$517,273				-\$16,167	\$501,107	\$9,260,196	\$4,024,795
2026	748,521	\$540,421				-\$16,652	\$523,770	\$9,783,965	\$3,765,176
2027	744,778	\$564,605				-\$17,151	\$547,454	\$10,331,419	\$3,467,317
2028	741,054	\$589,871				-\$17,666	\$572,206	\$10,903,625	\$3,127,902
2029	737,349	\$616,268				-\$18,196	\$598,072	\$11,501,697	\$2,743,370
2030	733,662	\$643,846				-\$18,742	\$625,104	\$12,126,802	\$2,309,900
2031	729,994	\$672,658				-\$19,304	\$653,354	\$12,780,156	\$1,823,390
2032	726,344	\$702,780				-\$19,883	\$682,877	\$13,463,033	\$1,279,439
2033	722,712	\$734,208				-\$20,479	\$713,729	\$14,176,761	\$673,329
Total	19,609,055	\$11,526,081	\$1,000,000	\$1,040,984	\$1,032,309	-\$422,612	\$14,176,761		

IRR	
10 years	22.7%
15 years	24.7%
20 years	25.4%
25 years	25.6%

1) Assumed Federal Tax Bracket = 35%

2) Operating Costs are Maintenance, Monitoring, Cleaning and Repairs

4/10/2008

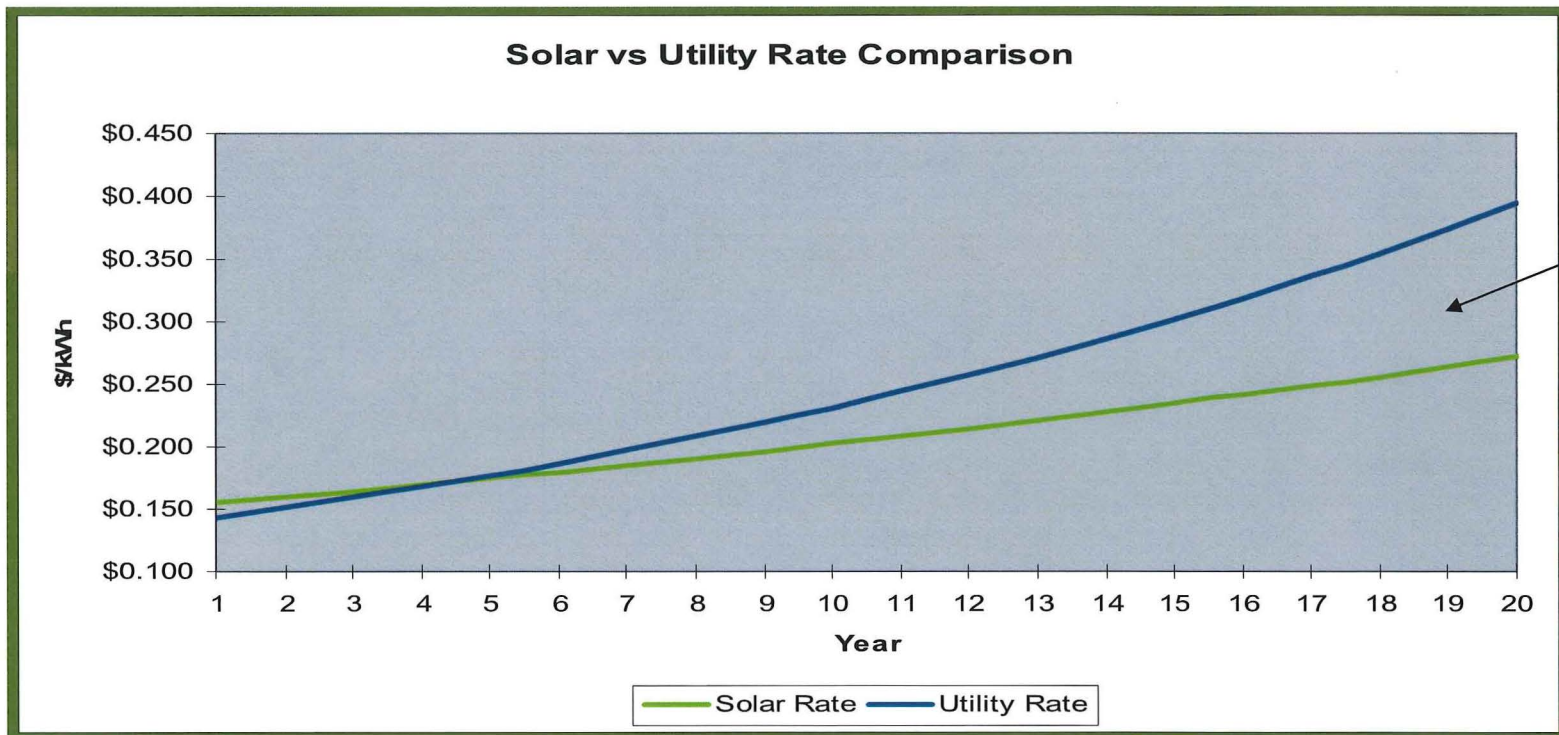
Systems Engineering Value To the Client

- **Standard Work:** Work must be standardized to eliminate variability in time and quality
- **Single Piece Flow:** Establish flow of product proceeding one at a time through all operations
- **Level Scheduling:** Scheduling of orders into a repetitive sequence to smooth order variation
- **Cycle Time:** Use of cycle time and lead time tools to increase throughput
- **Process Improvement:** reduce the # of process steps, WIP time, lead time strive to do it right the first time
- **Flow:** Have the product move along without stoppages, interruptions, or backflows
- **Pull:** Design, schedule and make exactly what CLIENT wants exactly when they want it
- **Takt Time:** Establish the pace of production needed to meet customer demand (panel installation)
- **JIT (Just In Time):** providing project supplies as the name suggests

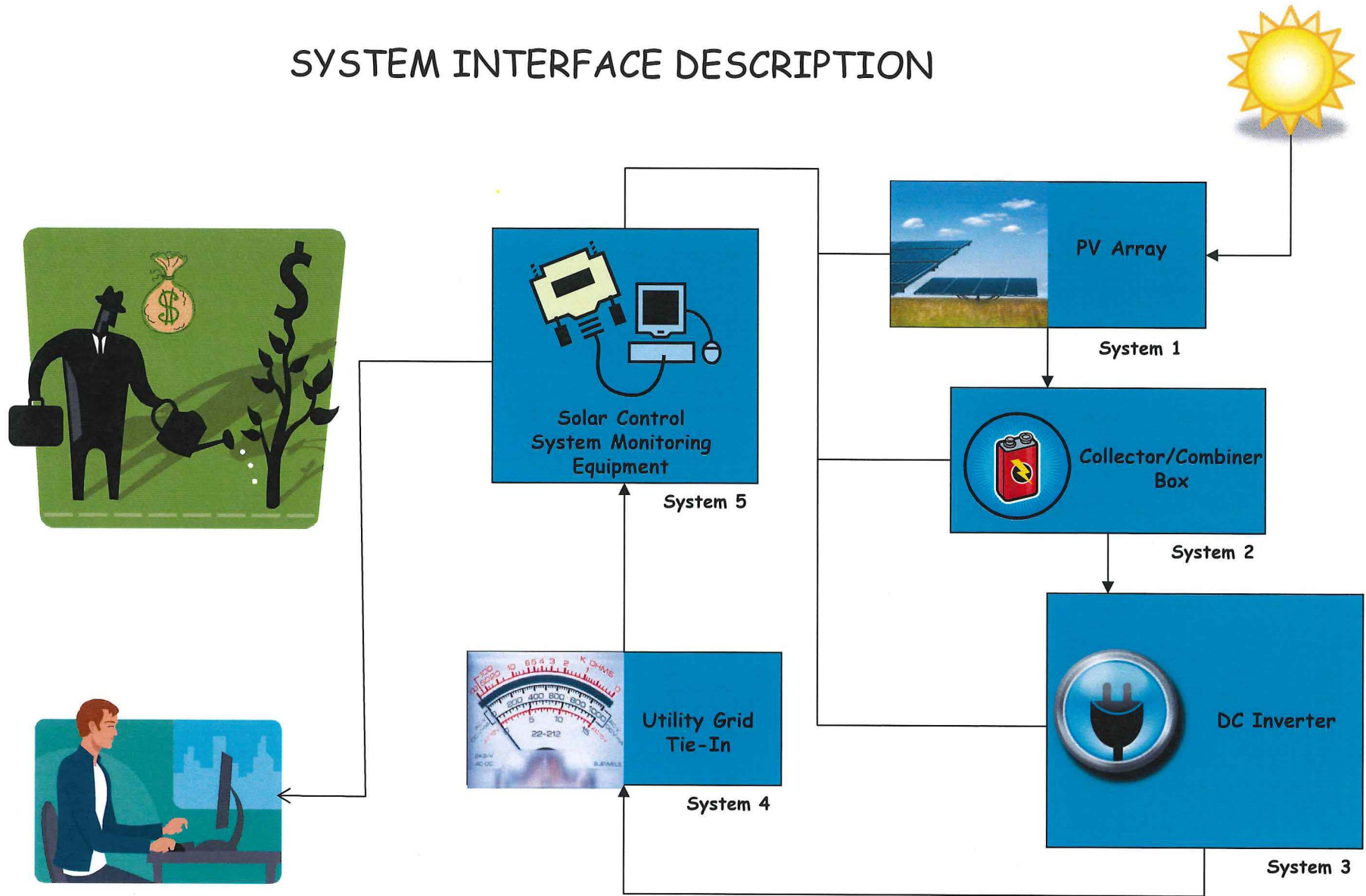


Solar Implementation Project Goal

- Start near current comparable utility rates
- Provide a competitive alternative against rising energy rates
 - Identify the comparable utility rate for pricing purposes (peak rates and demand charges)
 - Fully Utilize
 - The California Solar Initiative Rebate - \$ 0.39/kWh for 5 years
 - Federal Investment Tax Credit
 - Accelerated Depreciation



SYSTEM INTERFACE DESCRIPTION



SYSTEM, COMPONENT INTERFACES & INTERCONNECTIONS

Six Sigma Approach

Committed Leadership

Integration with top
level strategy

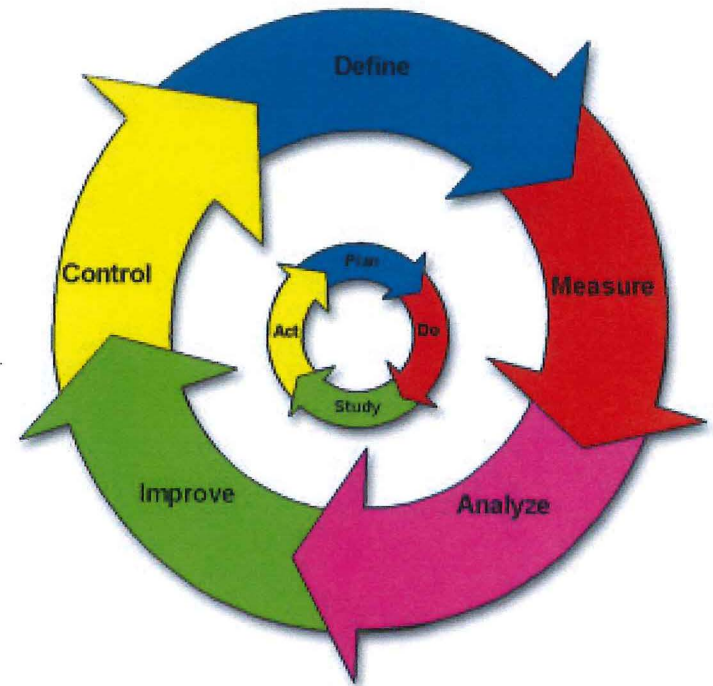
Business process
framework

Projects produce real
savings or revenue

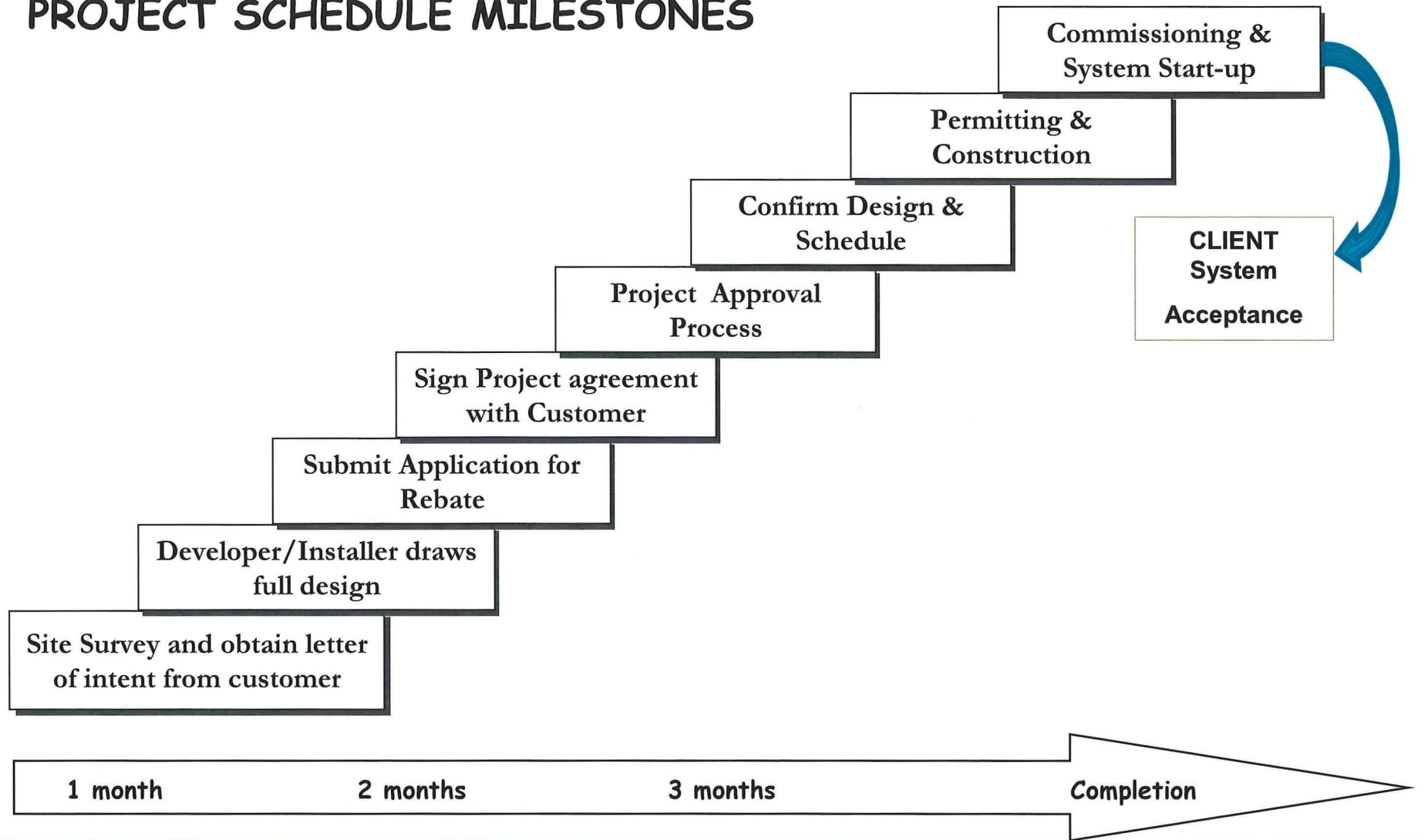
Full time six sigma
team leaders

Customer & market
intelligence network

Incentives for all

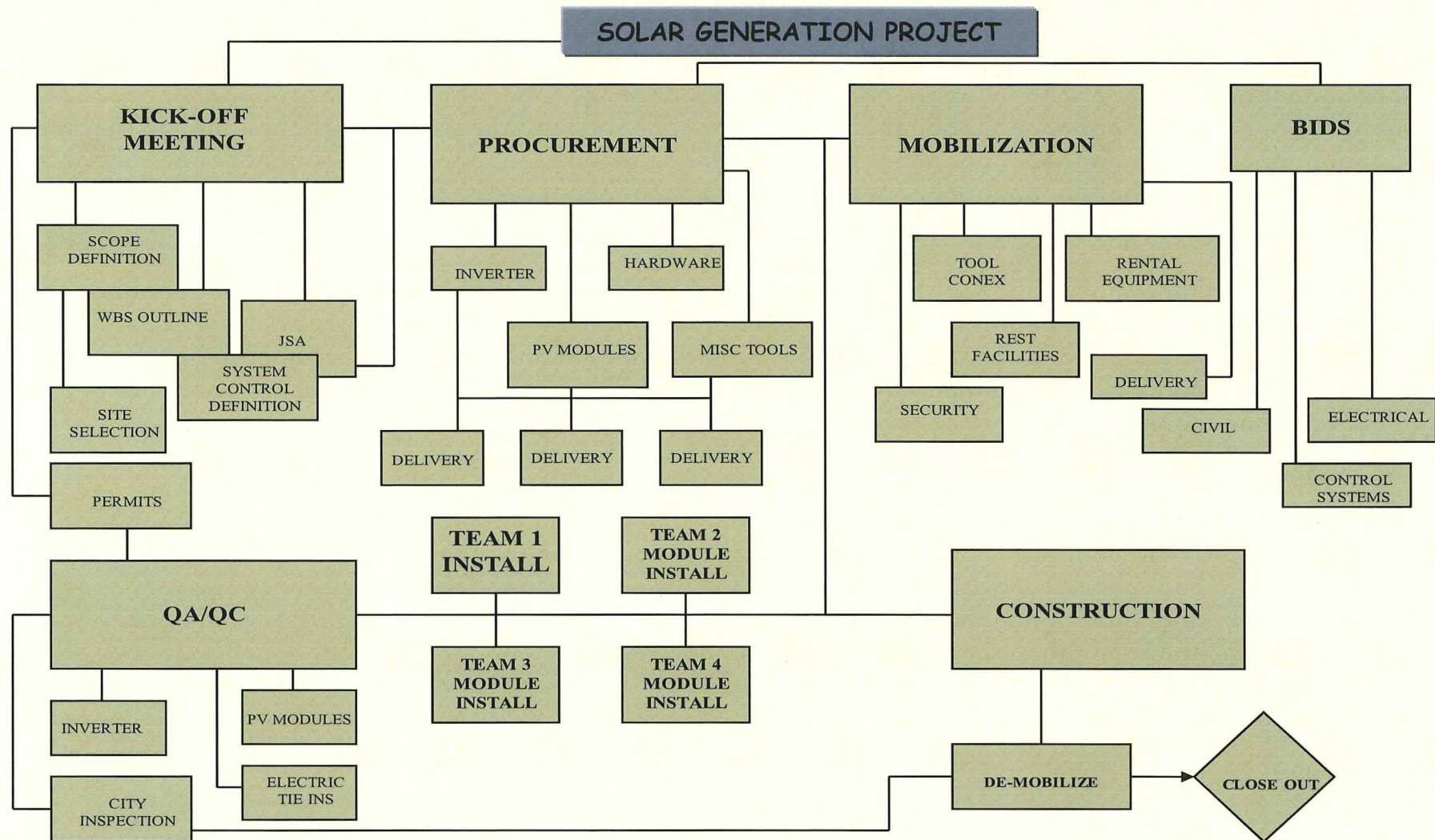


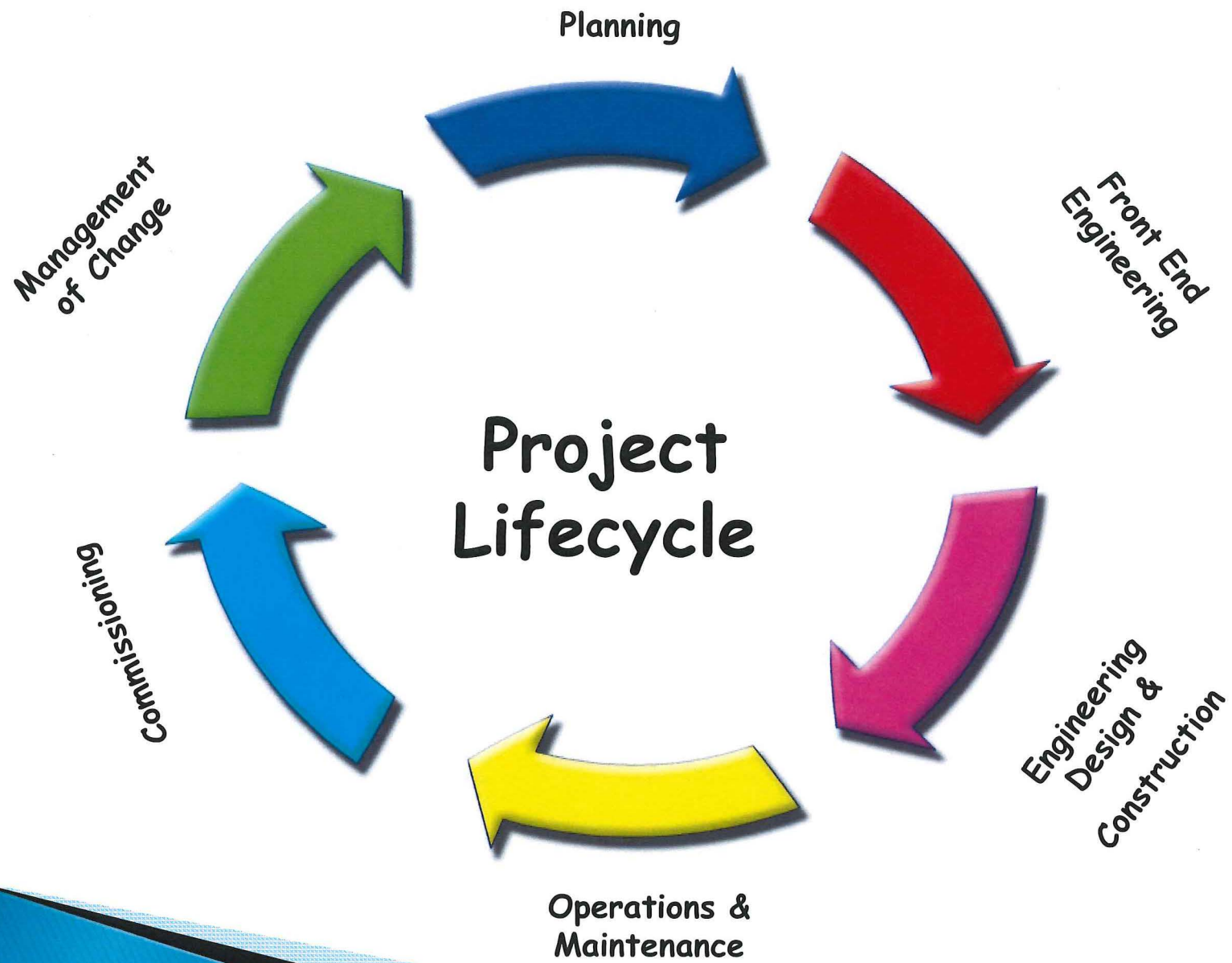
PROJECT SCHEDULE MILESTONES



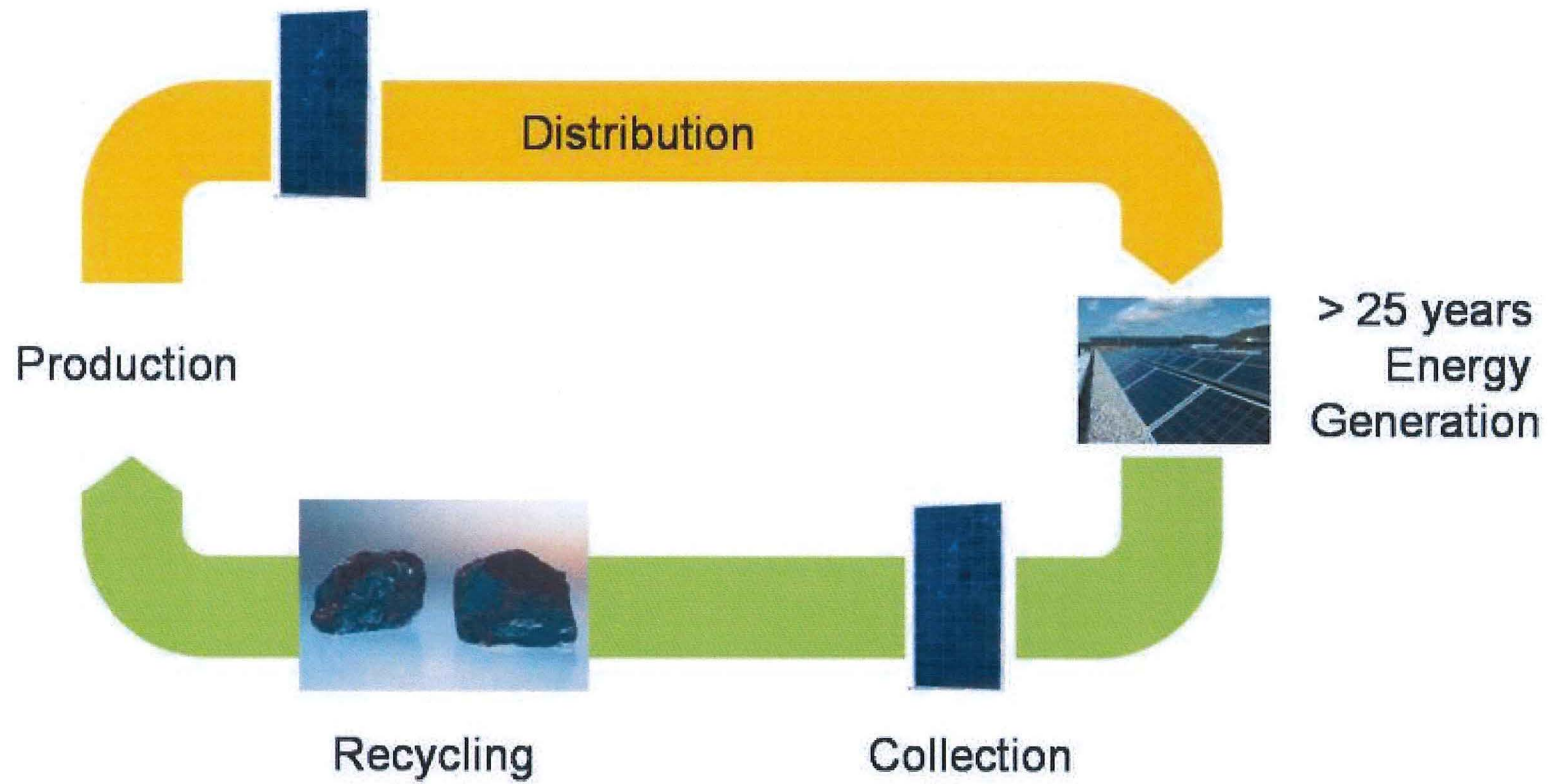
System Engineering and Integration Processes are Implemented at All Levels on this project

CURRENT STATE VSM





PV Product Life Cycle



SCHOTT
solar





Delivery & On Site Storage of
Solar Panels

Transfer of Panels From
Storage To The Roof





Layout of Roof Prior
To Installation

Solar Panel
Installation





Inverter / Transformer Installation

PV / Utility Connections





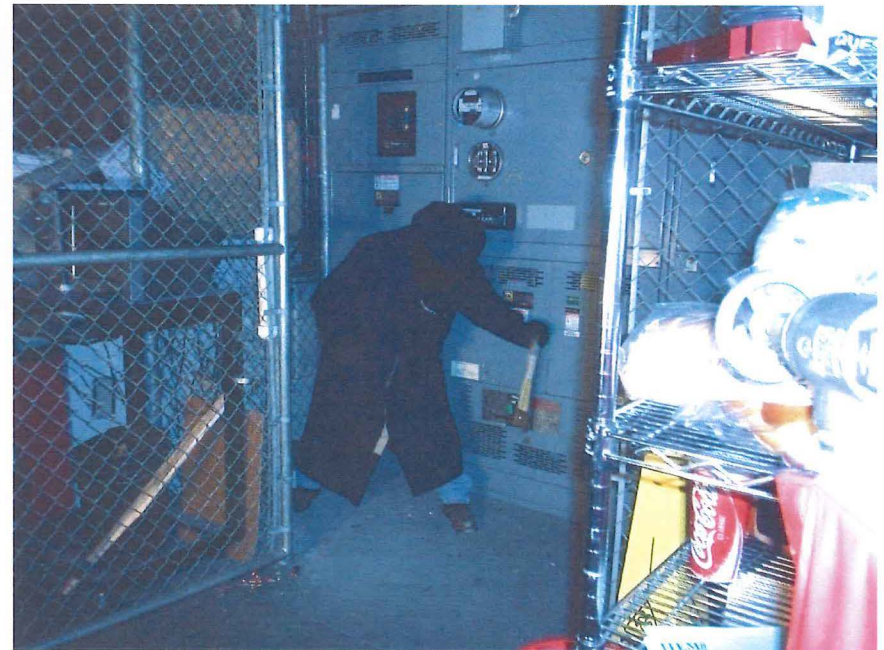
PV Combiner Array
Disconnect Installation

Monitoring System Installation





Proper use of PPE For Connection
To The Existing Utility



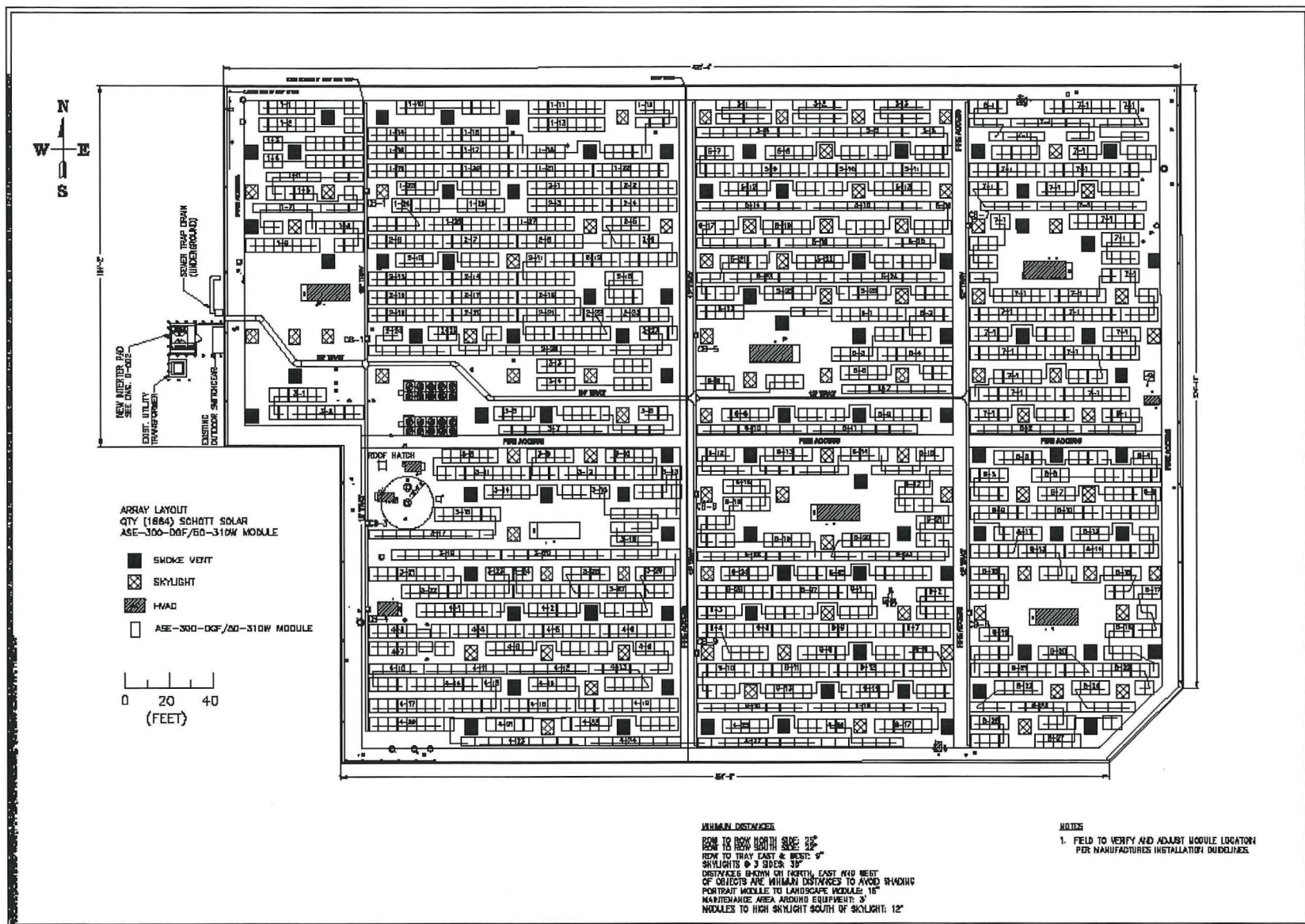
Connecting To The "GRID"



PV Array Complete & In Place

Cable Tray Complete & In Place





Design and Builders of Renewable Energy
 1600 W. Carson St., Suite 301
 Long Beach, CA 90810
 (562) 436-6000
 (562) 436-7079
 www.permacity.com
 OR California Contractors License #6078024

PROJECT INFORMATION:

**ROOF TOP
PV SYSTEM**

CURRENT ISSUE DATE:
2/18/09

REV.	DATE	DESCRIPTION	BY
0.0	12/10/08	INITIAL RELEASE	RHM
0.1	1/16/09	ISSUED FOR PERMITTING	
0.2	2/18/09	ITC	RHM

SOLAR INSTALLER:

 Engineering & Automation Specialists
 1600 W. CARSON ST.
 SUITE 100
 LONG BEACH, CA 90810

DRAWN BY: CHK. BY: APP. BY:
 DBH HD RM

STAMP:

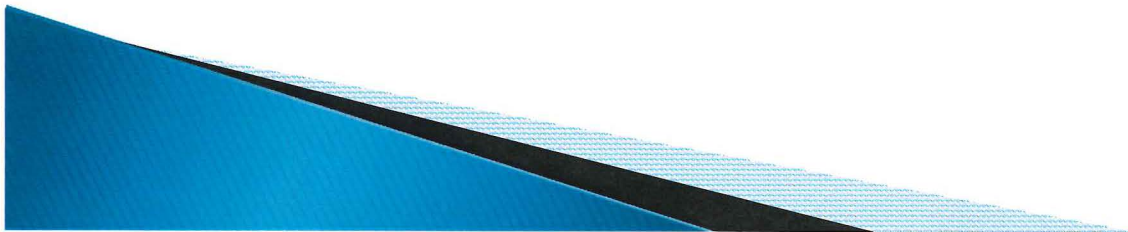
SHEET TITLE:
**ROOF ARRAY
LAYOUT**

SHEET NUMBER:
R-001

Project Roof Array Layout

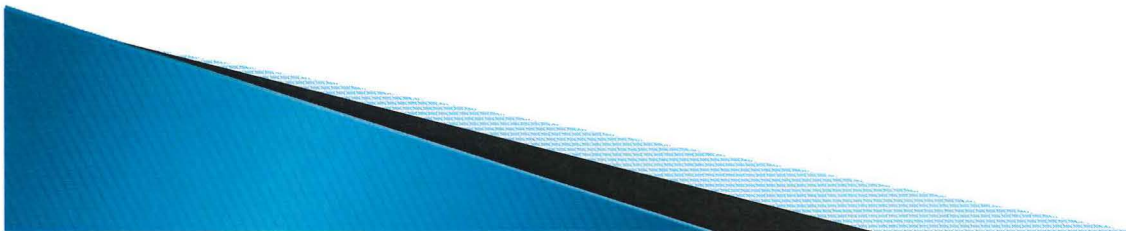
PRO's

- ✓ Increase Real Estate Net Value
- ✓ Independent Power Generation
- ✓ Virtually Maintenance Free
- ✓ Protection From Energy Rate Increases
- ✓ 20 - 25 Year Performance Warranty
- ✓ Grid Tie System - Eliminates Battery Requirement
- ✓ Code Compliant, Professionally Engineered & Installed
- ✓ Hands Free, Automated Seamless Operation
- ✓ Environmentally Safe



CON's

- ✓ Initial Investment Is Higher Than That Required For Conventional Electricity
- ✓ Efficiency Depends On The Numbers Of Hours Of Solar Light Available , Less Sunlight = Less Power
- ✓ Large surface areas are required to lay out panels
- ✓ The Manufacturing Process Requires Large Amounts Of Energy
- ✓ Global Dimming - caused by pollutants building up in the air and contaminating it, affects the effectiveness of PV Solar



Keys To Project Success

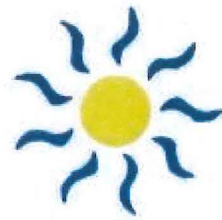
- Keep it simple
- Hire licensed, insured Solar specialist
- Understand system availability
- Be realistic about your load
- Learn local weather and seasonal shading conditions
- Know what hardware is available and at what cost
- Know the installation site before designing the system
- Plan periodic maintenance
- Perform a thorough economic analysis



Project Highlights To Date

- (9) CLIENT Stores have been completed and are up and running
- (5) CLIENT Stores are currently being worked on
- (8) CLIENT Stores are projected to be completed by year end
- CLIENT confirmed monthly savings of \$20,000 - \$30,000
- CLIENT interest in combining current system with Gas Generator
- GE Electric Proposal for 1.2 MW system being worked on
- BP Solar Proposal for (4) 600 KW systems being worked on
- Samsung Proposal for (3) 500 KW systems being worked on
- Over 30,000 MH worked for Eng/PM and Construction





COMMENTS / QUESTIONS

THE ONLY SUSTAINABLE ENERGY SOURCE TO SECURE
"RETURN ON INVESTMENT"!!!



