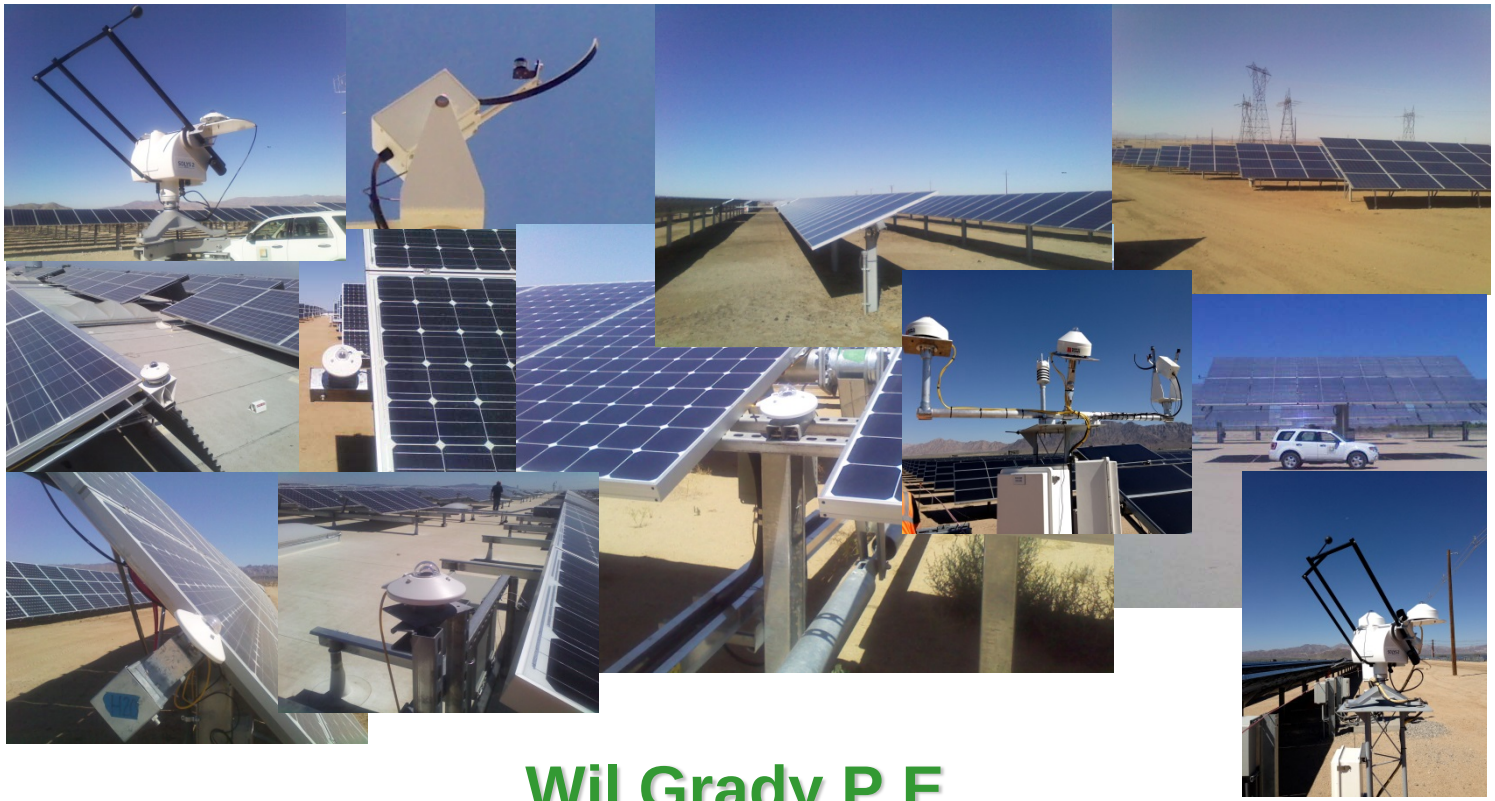
Solar Resource Measurement Importance



Wil Grady P.E.
Southern California Edison
Power Supply

NREL PV Solar Resource Workshop Denver 2015

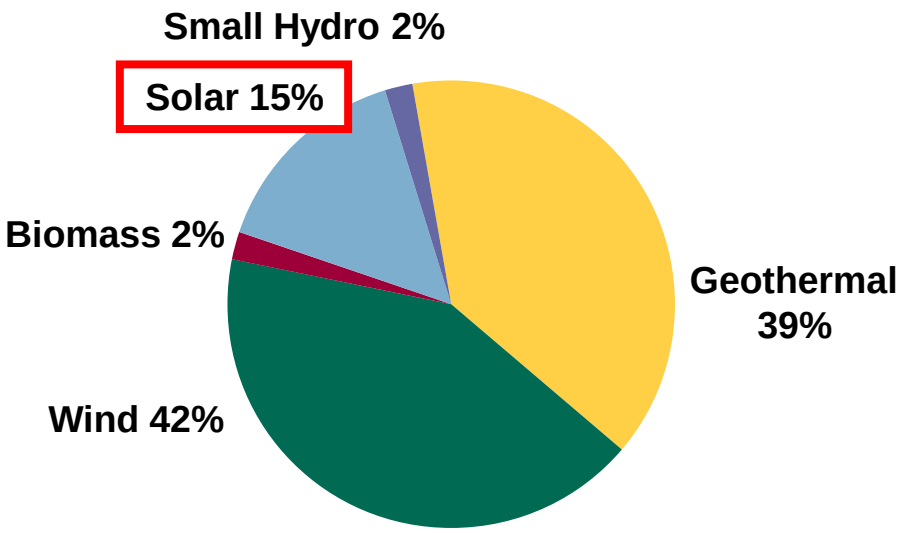
Overview of SCE

- Large service territory
  - 14 million residents
  - 4.9 million customer accounts
  - 50,000-square-mile service area
- National leader in environmental solutions
  - Energy efficiency
  - Renewable energy procurement
  - Electric transportation
  - Advanced meters
  - Smart grid

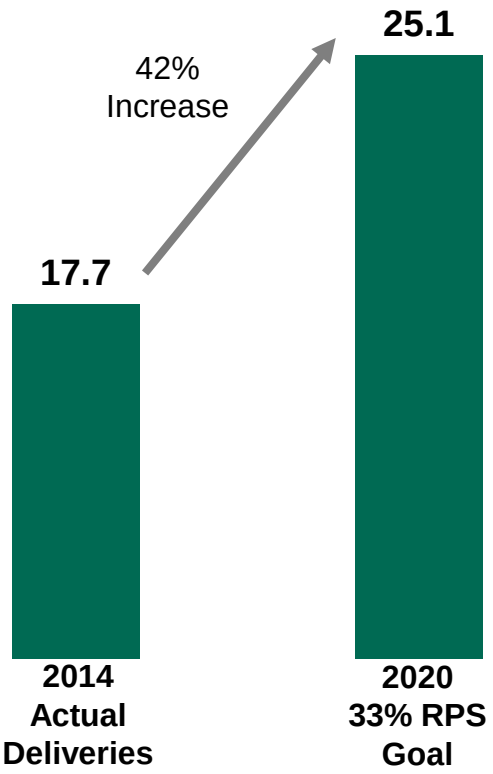
SCE's Solar Programs

SCE's Renewable Portfolio

Actual 2014 Renewable Resources:
23.4% of SCE's portfolio



Renewable Resources
(billion kWh)



In order to meet the 33% RPS requirement,
SCE will need to increase its renewable purchases by about 42%.
A large amount of this increase will be with solar resources.

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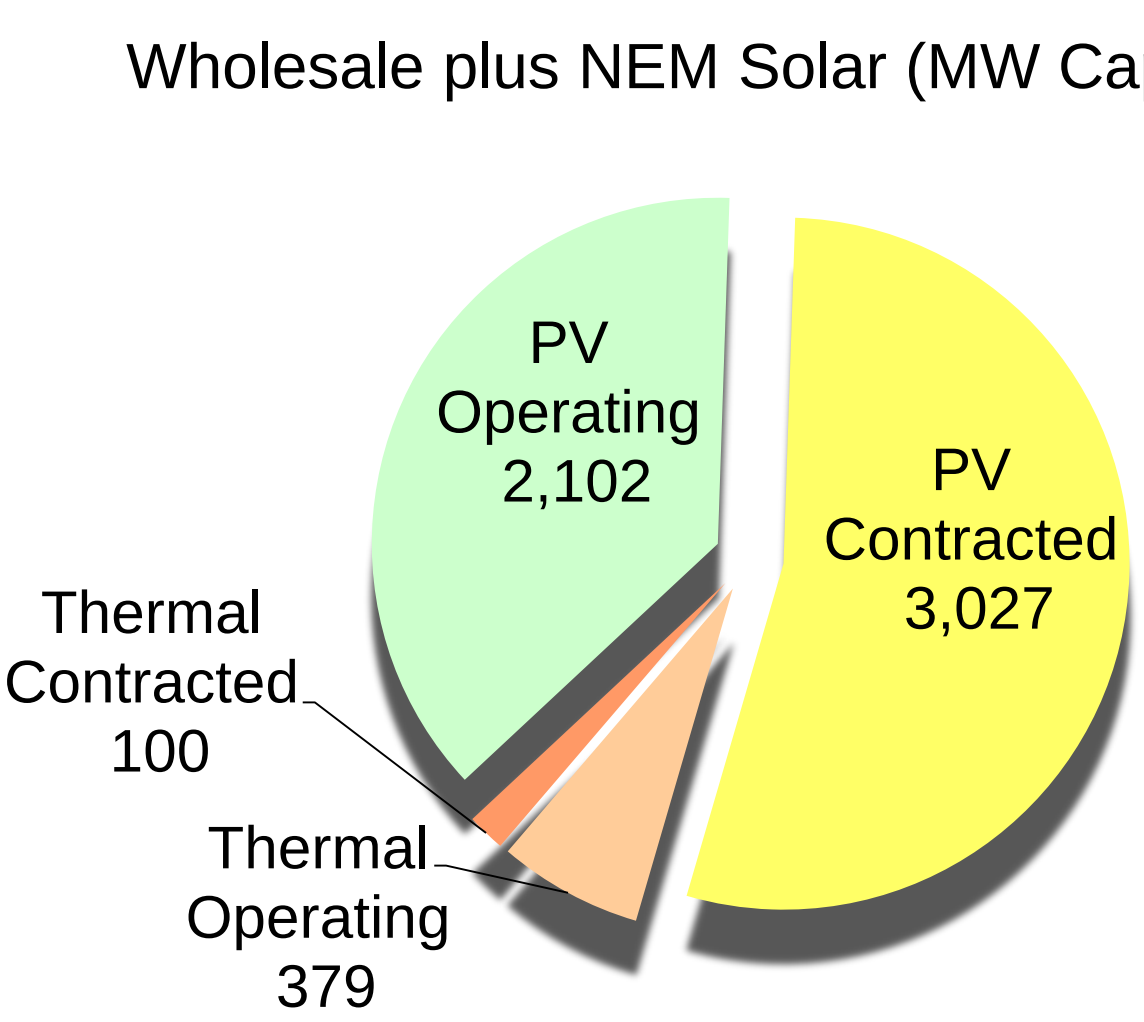
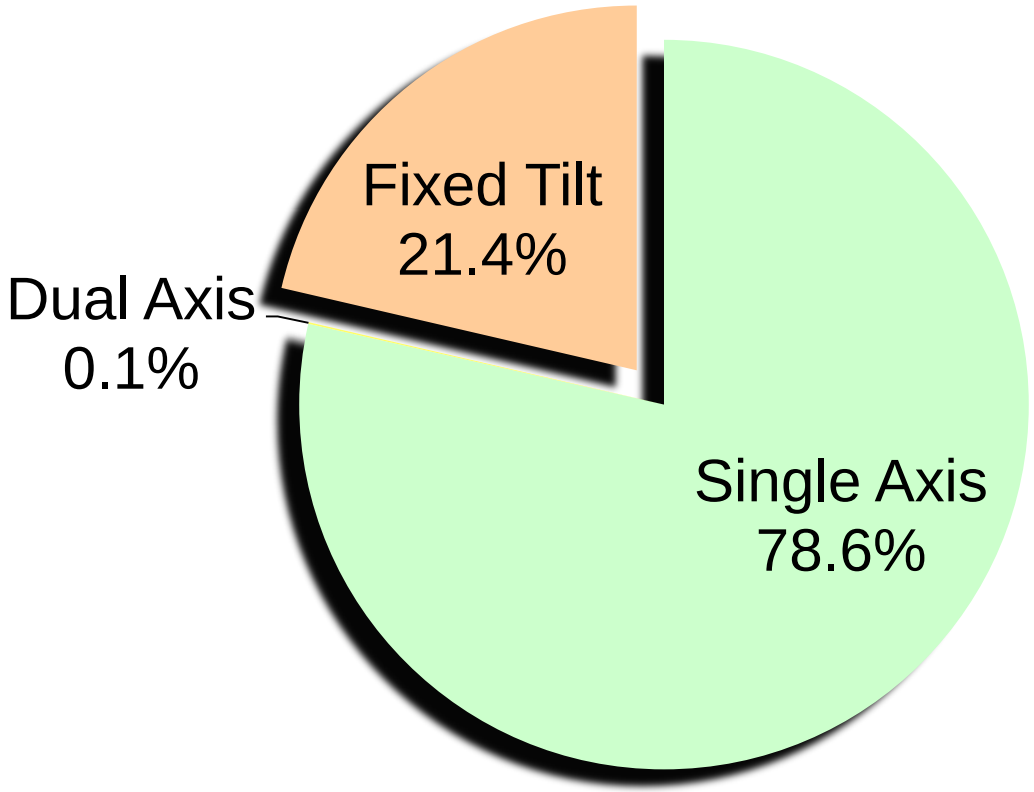
SCE Solar Portfolio as of December 2014



Solar PV Mounting Arrangements, SCE Portfolio

SCE's Solar PV portfolio is increasingly made up of single-axis tracking projects.



Observations

- SCE has been conducting renewables solicitations since 2002, and received its current competitive RPS proposals on February 2, 2015.
  - The majority of contracts recently executed by SCE have been Solar PV.
  - The domination of tracking solar arrays requires increased attention to the plane of array measurement.

- Solar Resource measurements are vital to solar project development and performance monitoring.
  - Poor measurements can directly impact a project's economics.
  - Consideration of the needs for true plane of array irradiance measurements must acknowledge model results can never replace direct measurements.

The Importance of Solar Resource Measurements

Solar resource measurements feed directly into the development, design and operational phases of a project's life-cycle:

Development & Design

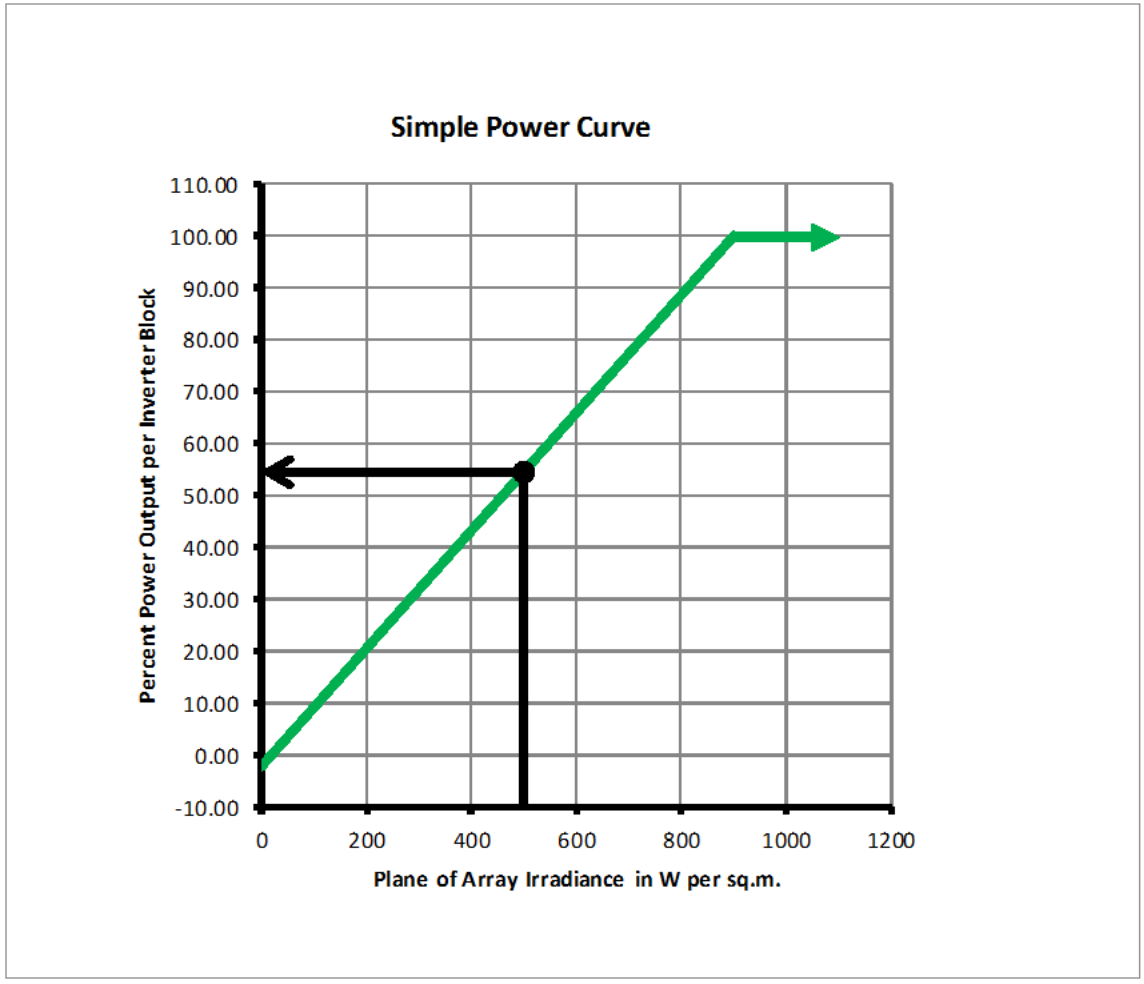
- ❑ Solar Resource Report
- ❑ Site Selection
- ❑ Equipment Selection
- ❑ Performance Models
- ❑ Performance Obligations
- ❑ Forecasted Revenues

Operation

- ❑ Energy Forecasts
- ❑ Performance Monitoring
- ❑ Cost Responsibility for Energy Deviations
- ❑ After the Fact Analysis of Delivery Obligations

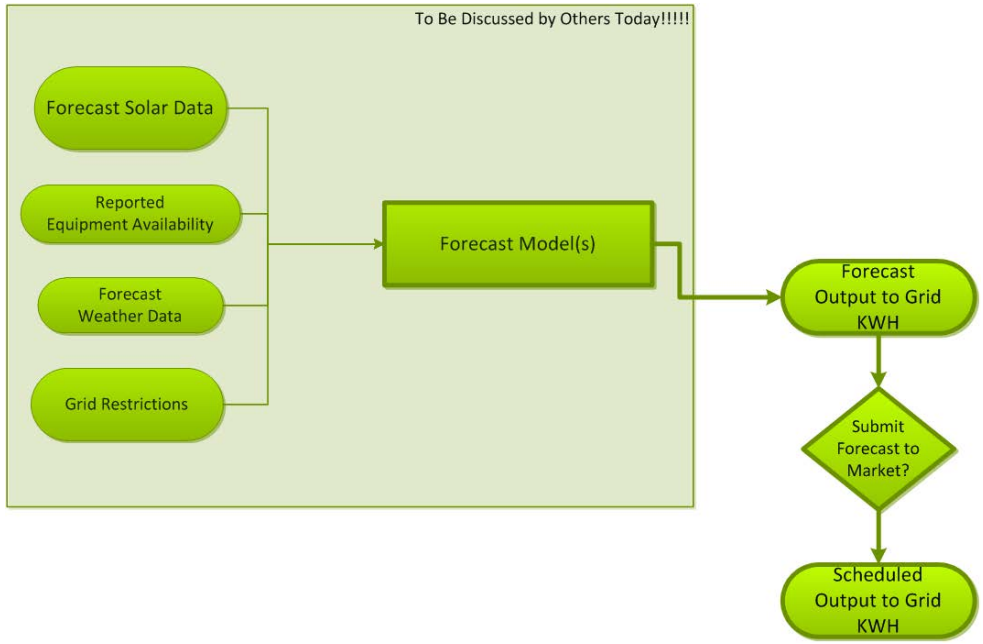
The Simple Power Curve

Input: Plane of Array Irradiance > Output: Electricity



Energy Forecasts in Organized Markets

Organized markets require accurate energy forecasts in order to optimize supply and cost-effectively meet demand.



Many Power Purchase Agreements (“PPAs”) include provisions requiring a minimum level of forecasting accuracy, and may penalize projects for over- or under-producing.

After the Fact Analysis ("AFA") of Plant Performance

Many PPAs include provisions guaranteeing a minimum level of energy production each year, and may include shortfall penalties.

- Production guarantees are generally a function of (i) energy yield factors (in kWh AC per kWp DC per year), and (ii) installed DC ratings, and may be adjusted for equipment degradation.
- Guarantees may be compared to actual recorded production, as adjusted for certain "lost output" events as defined in the PPA. Such events may include:
  - Grid outages
  - Curtailment orders
  - Uncontrollable forces (volcanic eruptions, wildfire, tornados, etc.)
- Measured solar irradiance and production model(s) are used to help make these adjustments, by determining what would have been produced but for the lost output event.

Accurate solar measurements are critical to accurate AFA, and could be the difference between meeting performance or incurring a penalty.

Summary

- Solar Resource measurements are vital to solar projects!
  - Measurements used for the development cycle impact site selection and project equipment design.
  - Production models need accurate solar and weather data.
  - Performance monitoring of projects demands accurate and reliable data to inform Operating and Maintenance decisions.
  - Power Purchase Agreements have performance obligations tied directly to the Solar Resource measurements.
  - Poor measurements can directly impact a project's economics, both hour to hour and at year-end.

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Questions?

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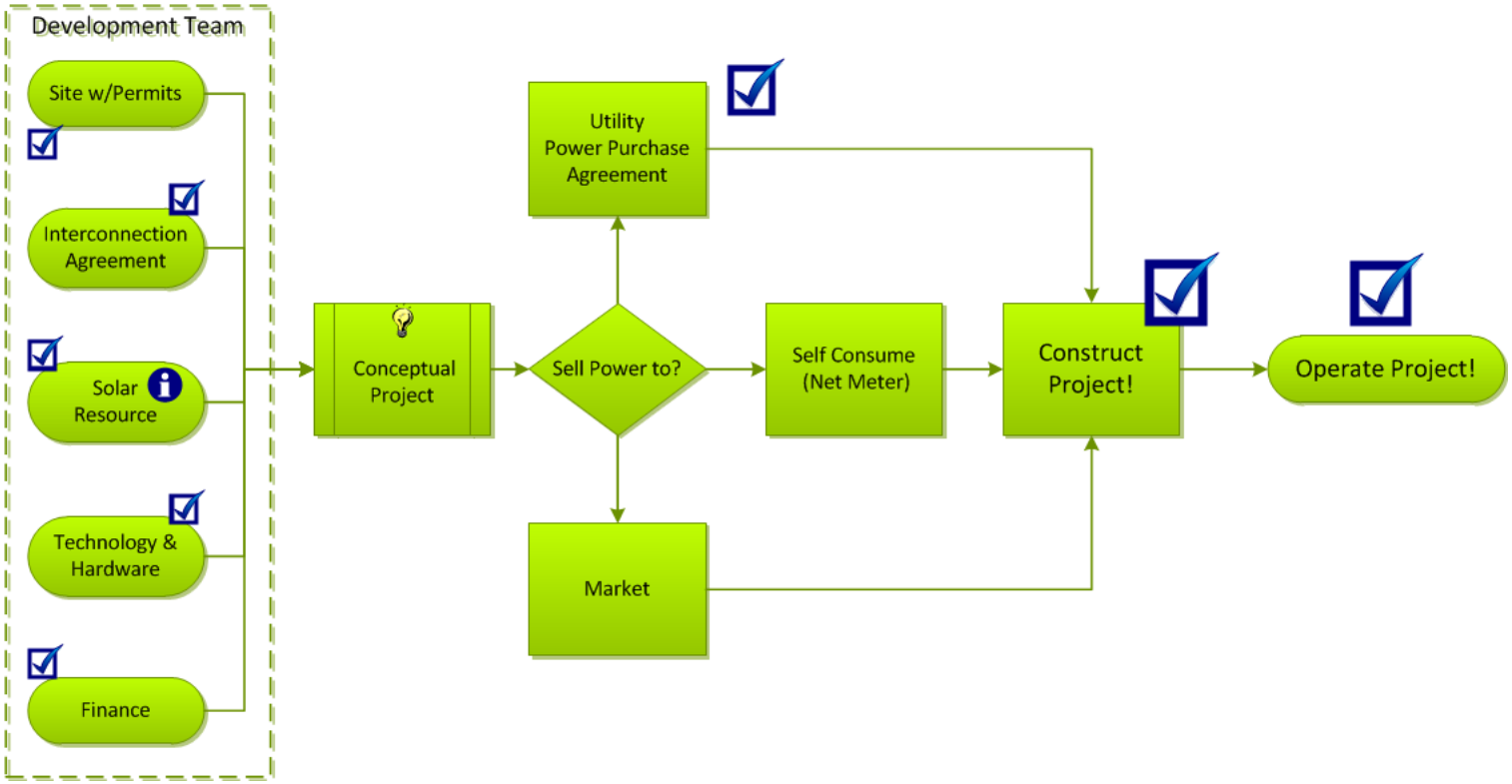
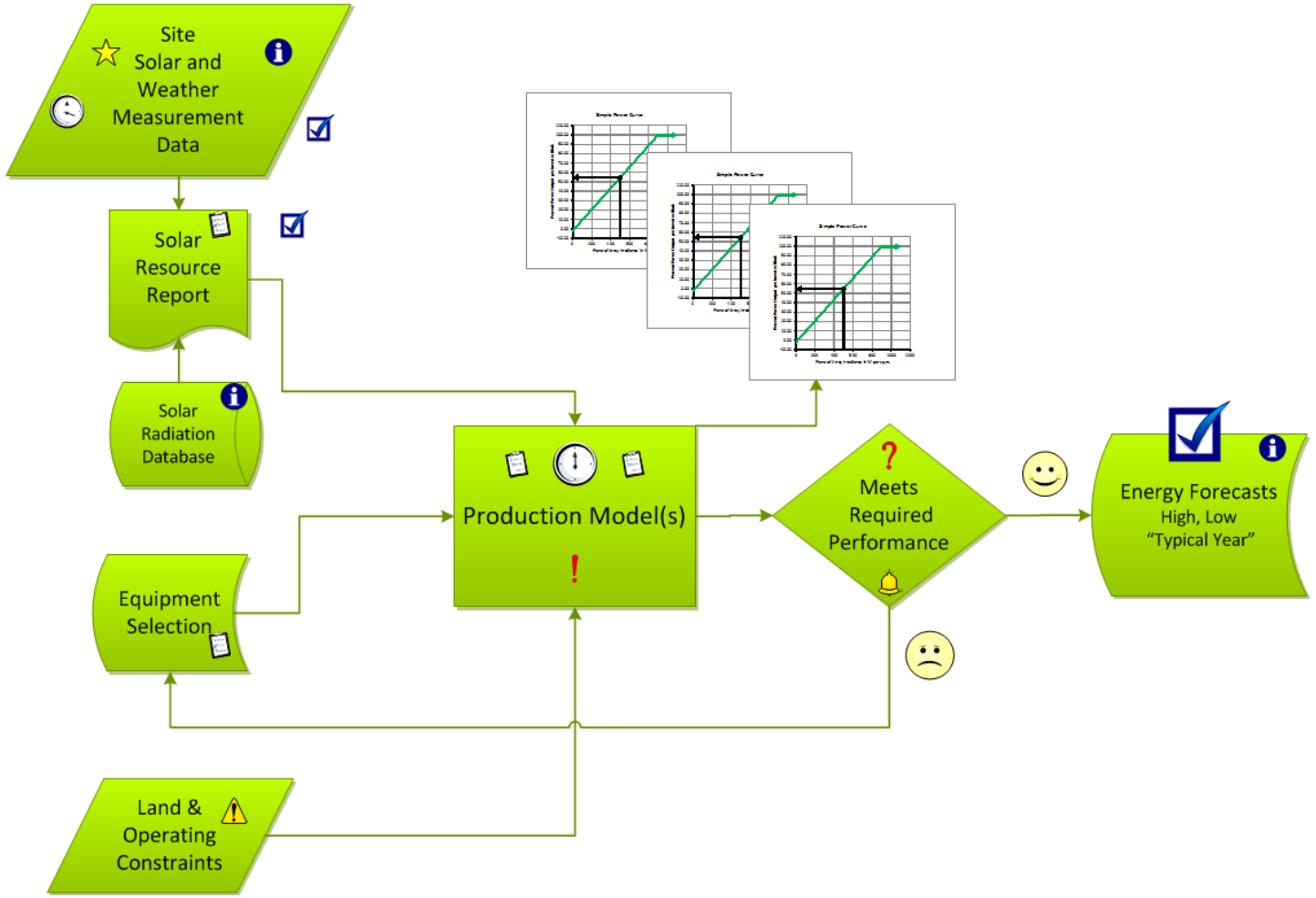
Back-up Slides

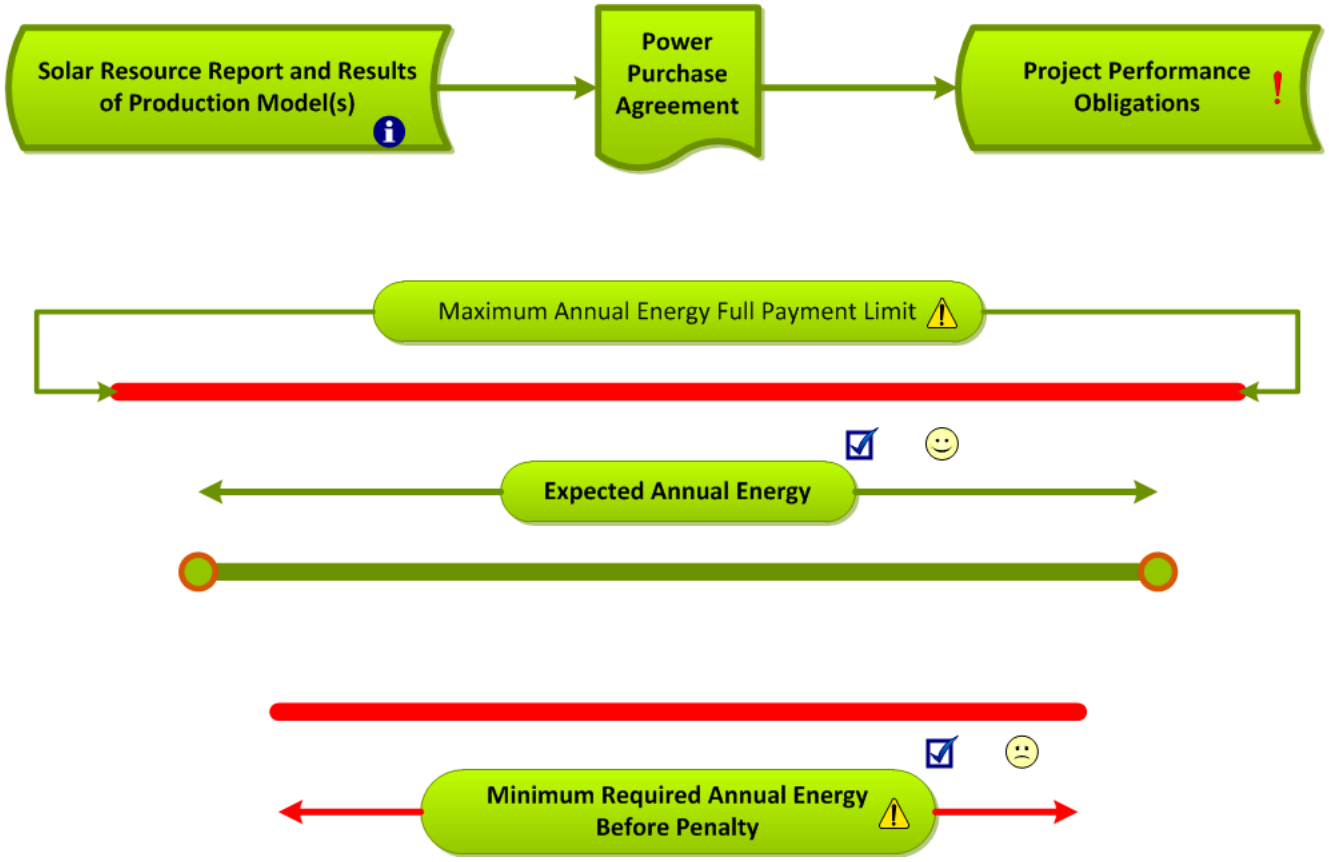
Project Development Process



Energy Forecasts and Design Must Have Solar Resource Measurements



Power Purchase Agreements have Performance Obligations Tied Directly to the Solar Resource Report and Modeling Energy Predictions



Solar Energy + Equipment = Electricity