COSEIA CERTIFICATION EXAM
STUDY GUIDE
DRAFT

This is the study guide for the COSEIA PV Installer Certification Exam. The purpose of this study guide is to outline the possible subjects that will be covered by the exam. The study guide and exam are in the process of being continually updated. COSEIA will continue to update this study guide as the exam evolves. If you have any comments or recommendations for the study guide, especially resources from the internet please send them Jon-Klima@PeoplePC.com. Thank you, the COSEIA Board.

TOPIC	SPECIFICS	RESOURCES
Solar Electric Overview	- Grid-Intertied - Solar Electric Panels - Array mounting Rack - Array DC Disconnect - Charge Controller - Grid-Intertied with Battery Backup - Battery Bank - System Meter - Main Dc Disconnect - Inverter - Stand Alone System - AC Breaker & Panel AC Disconnect - Kilowatt-Hour Meter - Backup Generator	- http://www.homepower.com/files/beginner/SolarElectricBasics.pdf - (M&O) Maintenance and Operation of Stand-Alone Photovoltaic Systems, A Publication of the Photovoltaic Design and Assistance Center, Sandia National Laboratories, Albuquerque, New Mexico 87185-5800. www.sandia.gov/pv/lib.htm
Basic Electricity	- Ohm's Law - Current - Resistance - Voltage - Amperage and Amp-hours - Power - Series - Parallel - AC & DCpower - DC power - Watts &Watt-hours - Energy	- HP72P98 - HP82P104 - HP83P114 - HP84P114 - HP87P100 - www.ibibilio.org/obp/electricCircuits/ - www.qsl.net/aa0ni/lsn02.html - www.outlawnet.com/~oclass/electricity/formulas.htm - www.uvi.edu/Physics/SC13xxWeb/Electrical/ElectricalConcepts.html

Solar Principles	- magnetic north/south - true south - solar declination - solar azimuth - peak sun hours - solar resource in Colorado - insolation, irradiance - optimal tilt angle - latitude - altitude -	- http://www.ngdc.noaa.gov/seg/geomag/declination.shtml - http://eosweb.larc.nasa.gov/sse/ - http://rredc.nrel.gov/solar/ - http://wrdc-mgo.nrel.gov/ - www.fallingrain.com/world/index.html - HP36P14 - http://www.nrel.gov/csp/maps.html#co
Site Assessment	- Effects of shading on a system - Array Orientation - Array Mounting Options - Balance of System Locations - Determining the pitch of a roof	- HP57P32
Load Analysis	- duty cycle of the load - power factor of motor driven loads - autonomy requirements - Watts v. Watt hours	- HP21P67 - HP37P46 - HP71P84
Energy Efficiency	- Parasitic loads - Phantom Loads	
Sizing	- Stand-Alone - Grid-Tie - Battery Backup -	- There are many ways to size the various photovoltaic systems, for the COSEIA exam one sizing method will be accepted. Please see sizing Examples at the end of the study guide for the accepted sizing methodology. -
PV Watts	- Understand how to use the program Understand all factors used within program	- http://rredc.nrel.gov/solar/codes_algs/PVWATTS/system.html

Overall Design	- total system efficiency goals - Stand – alone System - Hybrid-System - Grid-tie system - Grid-tie system with Battery Backup	- *Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices*, SAND87-7023. Sandia - National Laboratories, Photovoltaic Systems Assistance Center, Albuquerque, NM 87185-0753 - http://www.sandia.gov/pv - *Hybrid Power Systems: Issues and Answers*. Sandia National Laboratories, Photovoltaic Systems Assistance - Center, Albuquerque, NM 87185-0753 http://www.sandia.gov/pv - http://www.sandia.gov/pv/docs/PDF/CodeCorner94.pdf - http://www.sandia.gov/pv/docs/PDF/CodeCorner92.pdf - http://www.sandia.gov/pv/docs/PDF/CodeCorner88.pdf
Solar Panels	- I-V (Current – Voltage) Curves and how they are affected by Sun and ambient temperature - Open Circuit Voltage - Short Circuit Voltage - Maximum Power Voltage - Maximum Power Current - Blocking diode - Nominal Voltage - STC - PTC	- HP87P35 - HP105P96
Charge Controllers	- Sizing - State of Charge - Temperature Control - Bulk charging - Absorption charge - Float charge - Purpose of a LVD (Low Voltage Disconnect) - Shunt Type	- *Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices*, SAND87-7023. Sandia - National Laboratories, Photovoltaic Systems Assistance Center, Albuquerque, NM 87185-0753 http://www.trojanbattery.com/Tech-Support/BatteryMaintenance.aspx http://www.outbackpower.com/MX60.htm http://www.blueskyenergyinc.com/manuals.htm

	- Series Type - MPPT (Maximum Power Point Tracking)	
Inverters	- Sizing - square wave - modified sine wave - sine wave - Their Function - General Efficiency Location of installation in respect to grid-connection and panels	- http://www.consumerenergycenter.org/erprebate/eligible_inverters.html - HP23P53 - HP62P44
Batteries	- Deep Cycle - Gel Lead-Acid Battery - AGM-VRLA Battery (Absorbed Glass Mat – Valve Regulated Battery) Lead-Acd Battery - Flooded Lead Acid - Battery Wiring - Sizing - Equalization - State of Charge/Depth of Discharge - Rate of Charge - Temperature effect on Performance - Specific Gravity - Maintenance issues - Nominal Battery Voltage - Days of Autonomy	- Ref. NEC 480.8 (A)(1) Racks - Ref. NEC 480.6 (B) & NEC Handbook 480.1 Scope - NEC 690.9D - HP27P30 http://www.rollsbattery.com/ - http://www.trojanbattery.com/Tech-Support/MaterialDataSafetySheets.aspx
Battery Safety	- Working with hydrogen gases - Working around flooded lead-acid batteries - Proper ways to install batteries - Types of tools to use around batteries	- NEC 480.6 (B) & NEC Handbook 480.1 Scope - (HP#27) Overcurrent Protection for Battery-Powered Systems, Christopher Freitas, Home Power #27, Pages 26-29, February/ March 1992. www.homepower.com - http://www.trojanbattery.com/Tech-Support/MaterialDataSafetySheets.aspx

		- http://www.rollsbattery.com/
Components	Conductors/Cables/Wires ▪ General Types used in PV systems ▪ How to size ▪ Voltage drop ▪ Conduit issues ▪ Voltage drop ▪ Color Coding ▪ Conduit/Raceway sizing Fuse ▪ AC Vs. DC Fuses ▪ Current-limiting Fuses Circuit Breaker ▪ Branch Circuit ▪ Supplementary Applications ▪ DC & AC Rated ▪ Dual-Rated AC Breakers ▪ Used as a Disconnect ▪ Current Limiting Breakers Disconnect	- http://www.sandia.gov/pv/docs/PDF/Code.Corner.104.Final.pdf - http://www.sandia.gov/pv/docs/PDF/CodeCorner85.pdf - http://www.sandia.gov/pv/docs/PDF/CodeCorner84.pdf - http://www.sandia.gov/pv/docs/PDF/CodeCorner83.pdf - http://www.sandia.gov/pv/docs/PDF/CodeCorner82.pdf - http://www.sandia.gov/pv/docs/PDF/CodeCorner81.pdf - http://www.sandia.gov/pv/docs/PDF/whrtocdcrnr.pdf - http://www.sandia.gov/pv/docs/PDF/bigcdcrnr.pdf - http://www.sandia.gov/pv/docs/PDF/awgcdcrnr.pdf - http://www.sandia.gov/pv/docs/PDF/surfcdcrnr.pdf - http://www.sandia.gov/pv/docs/PDF/clarcdcrnr.pdf - Ref. NEC 200.6 (A) & NEC Handbook 690.31 (D) - Table 250-122 of the 2005 NEC
Utility Connection	- *NEC* 690.64(B) - the connection to the panel must be made via a dedicated circuit breaker or fusible disconnecting means, - the sum of the ampere ratings of the overcurrent devices in circuits supplying power to a busbar or conductor shall not exceed the rating of the busbar or conductor - the interconnect point shall be on the line side of all ground-fault protection equipment, - equipment containing overcurrent devices in circuits	- *NEC* 690.64(B) - *IEEE 1547* - *UL 1741* http://www.nmsu.edu/~tdi/pdf-resources/CC111.pdf

	supplying power to a busbar or conductor shall be marked to indicate the presence of all sources.	
Installation Safety	- Working safely with PV systems requires a fundamental understanding of electrical systems coupled with common sense. To help keep a safe working environment it is recommended to do atleast the following: - Reduce workplace clutter. - Be extra cautious and organized on sloped roofs. - Don't leave tools lying on a slope roof without beng secured. - While working on a roof be prepared for all elements, cold, sun, heat, wind etc… - It is essential when traversing an attic to support one's weight by stepping *only on the ceiling joists or trusses*. - Take your time and make the proper electrical and structural connections -	- http://www.sandia.gov/pv/docs/PDF/Wiles99.pdf - http://www.sandia.gov/pv/docs/PDF/Code_Corner_96.pdf
Mounting Systems	- Fixed Tilt - One-axis Trackers - Two-axis Trackers - Durability in design of mounting structures	- http://www.greenbuilder.com/sourcebook/Photovoltaic.html#MOUNTING - http://www.pvresources.com/en/arhiv/bifactracking.pdf - http://www.ecobusinesslinks.com/solar_tracking_sun_trackers.htm - www.unirac.com
Utility Connection	- Net Payment - Peak Shaving - Net Metering - Demand Side Management - IEE1547	- http://www.epa.gov/greenpower/whatis/glossary.htm - http://www.denvergov.org/admin/template3/forms/NEC%20705.pdf - NEC 690.64 (B)(2) - NEC 408.36 (F)

	- NEC Article 705 - Back-fed breakers - Bus bar conductor sizing in main panel - Breaker sizing in main panel	- NEC 690.64 (B)(5)
Renewable Energy Credits	- Definition - Their use -	- http://www.epa.gov/greenpower/whatis/glossary.htm
NEC CODE	- Understand section 690 and all other relevant information in respect to PV installation	- http://www.sandia.gov/pv/docs/PDF/WilesCC110.pdf - http://www.sandia.gov/pv/docs/PDF/CodeCorner105.pdf
GENERL REFRENCES	http://www.nmsu.edu/Research/tdi/public_html/Photovoltaics/Codes-Stds/PVnecSugPract.html	

Notes: HP = Home Power
P = Page

Stand-Alone PV System Sizing Example "Courtesy of Solar Energy International (c) 2006"

Load Analysis:

Total AC connected Watts = _____

Total DC connected Watts = _____

AC Average Daily Load = _____

DC Average Daily Load = _____

Inverter Sizing:

Total AC connected Watts ÷ DC System Voltage = _____ Max. DC Amps Continuous

Battery Sizing:

((AC Average Daily Load ÷ Inverter Efficiency) + DC Average Daily Load) ÷ DC System Voltage = Average Amp-hours/Day

((Average Amp-hours/Day x Days of Autonomy) ÷ Discharge Limit) ÷ Battery AH Capacity = Batteries in parallel

DC System Voltage ÷ Battery Voltage = Batteries in Series x Batteries in Parallel = Total Batteries

Array Sizing:

(Average Amp-hrs/day ÷ Battery Efficiency) ÷ Peak Sun Hrs/day = Average Amp-hours/day

Average Amp-hrs/day ÷ Peak Amps/module = modules in parallel

DC System Voltage ÷ Nominal Module Voltage = Module in Series x Batteries in Parallel = Total Modules

Controller Sizing:

Module Short Circuit Current x Modules in Parallel x 1.25 = Array short circuit amps = Controller Array Amps

DC Total Connected Watts ÷ DC system voltage = Maximum DC Load Amps

Utility-Interactive / Grid-Tie PV System Sizing Example "Courtesy of Solar Energy International (c) 2006"

Electric Load Estimation:

1. Approximate monthly and daily average energy usage

Yearly average energy consumption: _____ kilowatt-hrs/yr

_____ Kilowatt-hrs/yr ÷ 12 months = _____ average Kilowatt-hrs/month

_____ Average Kilowatt-hrs/month ÷ 30 days = _____ kilowatt-hrs/day

(This is your Average Daily Load)

_____ % of power to be generated from PV System

_____ Kilowatt-hrs/day x _____ % of power to be from PV

= _____ PV System Kilowatt-hrs/day

Array Sizing:

2. Find out your Average Sun Hours Per Day: _____
3. Figure out the PV system kilowatts needed (the initial size of the array):

_____ PV System Kilowatt-hrs/day ÷ _____ average peak sun hours per day

= _____ PV System Kilowatts

4. Factor in inverter efficiency

_____ PV System Kilowatts ÷ _____ inverter efficiency

= _____ PV array System Kilowatts needed

_____ PV array system Kilowatts x 1000 watts/Kilowatt = _____ PV array watts