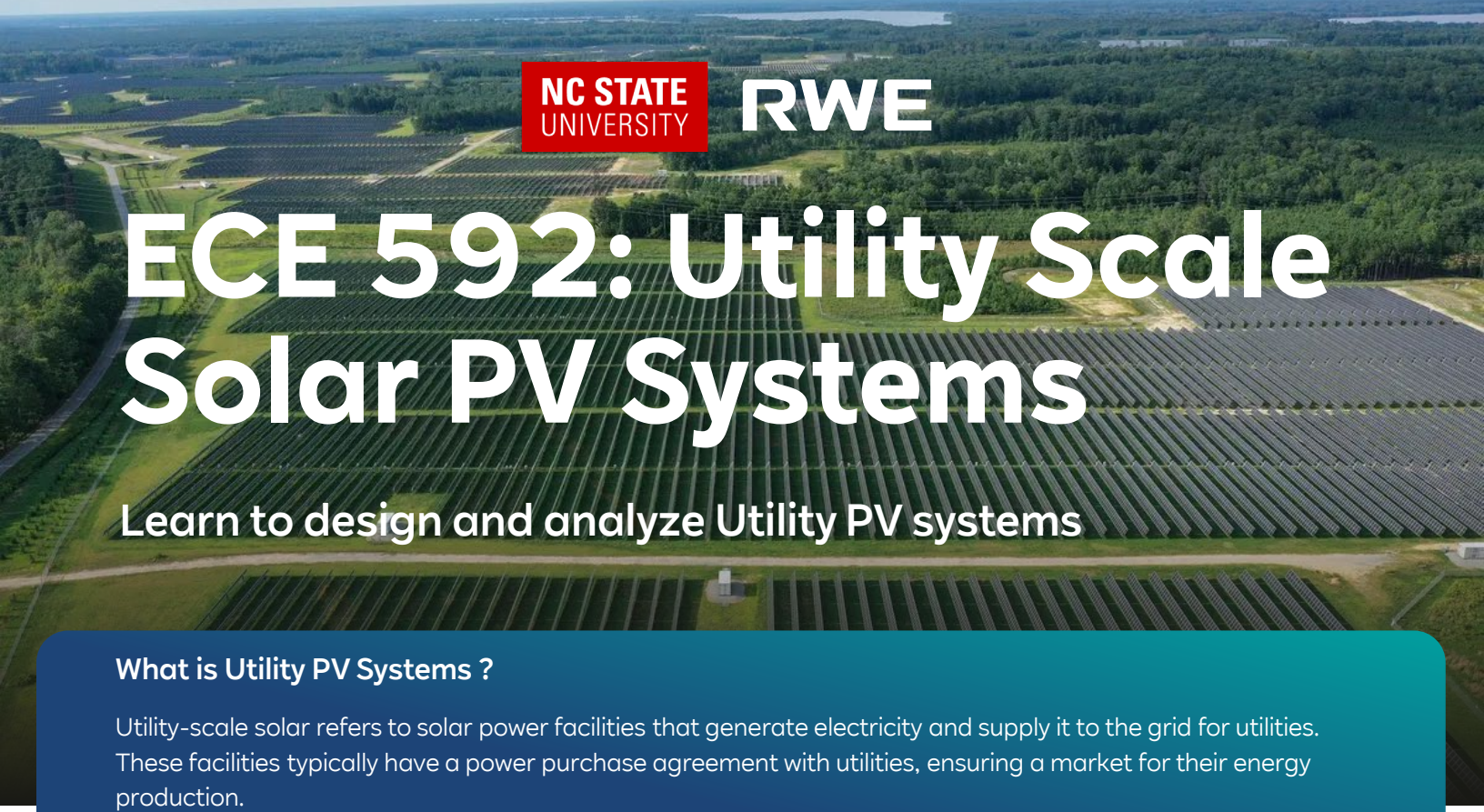

NC STATE UNIVERSITY RWE

ECE 592: Utility Scale Solar PV Systems

Learn to design and analyze Utility PV systems

What is Utility PV Systems ?

Utility-scale solar refers to solar power facilities that generate electricity and supply it to the grid for utilities. These facilities typically have a power purchase agreement with utilities, ensuring a market for their energy production.

National Renewable Energy Laboratory labels a solar project “utility-scale” if it has 5 MW of solar energy capacity. In the course students would be designing a 100MW+ PV project.

What the Course Covers?

It covers the length and breadth of what goes into designing a PV Solar plant and how to make engineering decision by effective Electrical, Civil, Energy Estimation and Financial Analysis

Main skills taught:

- Identifying land constraints like Wetlands, Transmission Capacity, Local Ordinances, Financial Incentives, Civil Constraints, etc. to map buildable area that’s constructable.
- Drafting a layout of the site using AutoCAD 3D and PVFarm to understand various Civil, structural and Electrical Design parameters necessary to produce a buildable PV layout.
- Performing Electrical Analysis by understanding PV modules characteristics and Inverter Requirements to electrically design the system
- Using PVsyst to perform Energy Assessment and select the optimize scenario
- Financial Analysis to cover CAPEX and OPEX costs and estimate different revenue streams from PV project.

Benefits to Students

Design Actual PV Plants

1. Actual PV projects would be used to teach students to ensure the learning matches the Industry standard.
2. Starting from selecting counties to understanding requirements of Energy Contracts for PV plant.
3. Latest Industry Scenarios would be used to challenge students and give opportunity to solve real life problems.

Interaction with Industry Experts

1. All lectures are delivered by working professional that are working on PV projects in their daily life.
2. Will have the opportunity to interact and ask questions
3. Learn how to analyze and what factors affect the decisions when designing a PV plant.

Gain Valuable Skills for your Resume

1. State of the Art Software like AutoCAD 3D, PVCase, PVFarm and PVsyst would be used.
2. Diverse set of skills including Meteorological .Civil, Electrical, Structural, financial and Statistical would be taught
3. Skills are targeted towards helping students make a career in PV Systems Design

About RWE

RWE is a renewable energy company powering America's clean energy future. In the U.S., we operate a portfolio of 9+ GW installed capacity of onshore wind, solar and battery storage. As a preferred partner for communities, landowners and suppliers, we employ more than 1,900 team members nationwide.

Learn more:

Lecture Outlines for ECE592:Utility Scale Solar PV Systems

Date:12/09/2024

1. **Utility PV Introduction –Current Market Trends**
    a. History of PV Solar
    b. Climate Change – Role of PV
    c. Current Market Trends in PV
    d. Energy Source Distribution in different ISO's
    e. Role of PV in Current and Future Electric Grids
    f. Future Outlook of PV Markets

2. **Site Selection – Solar Greenfield**
    a. Phases of Solar Project Development
    b. RFP/State/Federal Policies for Renewables Addition
    c. Transmission Constraints to consider in Site Selection
    d. Environmental Constraints to map in Site layout
    e. ITC Considerations – Energy Communities
    f. Other Site Constraints to model
    g. Evaluating Site for PV, BESS, gH2 and Wind

3. **PV Meteorological Data and Campaign**
    a. Development vs Operational Met Station
    b. Different weather sensors for PV site – IEC/ISO Standards
    c. Type of Meteorological Data- Satellite, Modeled, Tuning/Site Adaptation Met Data
    d. Distributed Met Sensors – Soiling, Albedo, POA
    e. IEC and ISO Standards
    f. Bias and Uncertainty in Met Data models

4. **PV Modules**
    a. Bifacial vs Monofacial Modules
    b. Evolution of PV modules
    c. Current Trends in PV Modules – Half Cut, Multi Bus bar etc
    d. Current PV Cell Tech - PERC, TOPCON and HJT Modules
    e. Review of PV Datasheets
    f. String Sizing
    g. PV module losses – IAM, LID, LeTID etc

5. **PV Trackers**
    a. Fixed Tilt vs Single Axis Tracker
    b. GCR and Row Design
    c. Tracking Algorithm – Backtracking
    d. Extreme Weather Mitigation
    e. Smart Track System

6. **Civil and Structural Topics in PV**
    a. Survey – Topographic Model and Boundary Survey
    b. Geotech – Soil Type, Corrosion Potential, Pile Testing, etc.
    c. Hydrology – FEMA Zones, Pre- & Post-Construction Flood Modeling, Stormwater Basins
    d. Structural – Wind & Snow Loads, Pile Design, Alternatives
    e. Site Grading – Slope Limits for Tracker Design, Grading vs Pile Length analysis
    f. Road Design – Private Access Road Cross Section, Public Road Evaluation
    g. Other Civil Topics – Trenching, Drain Tile Impacts, Restoration, etc

7. **PV Inverters**
    a. Function of inverter in PV plant
    b. DC:AC Ratio, Inverter Loading Ratio
    c. Inverter Clipping and Efficiency Curves
    d. ISO/NERC Requirements
    e. String vs Central Inverters
    f. Inverter Sizing Calculations

8. **Grid Compliance and Requirements**
    a. Introduction to the various parties involved
    b. NERC standards and requirements for Generators (PV project)
    c. Non-Compliance and Self reporting
    d. Plant Controls Requirements – AVR, PFR
    e. ERCOT Checklists for PV Commissiong

9. **PV Commissioning Test**
    a. LOTO and HSE
    b. Cold and Hot Commissioning
    c. Drone Inspection of PV Plant
    d. NETA Testing Standards of PV Plant
    e. Capacity and Availability Test

10. **PlantPredict**
    a. Marking Site Constraints in site layout using PlantPredict
    b. Selecting Weather Data and other weather inputs
    c. Designing DC block in PlantPredict
    d. Sizing Inverters to meet the POI requirements
    e. Running Shading analysis in PlantPredict
    f. Generating PV layout and running Energy estimate in PlantPredic
    g. Exploring other functions in PlantPredict

11. **PVCase**
    a. Using Civil3D to import KMZ and setting workspace
    b. Importing Contour Data and creating Terrain Mesh
    c. Building Typical PV rows as per Tracker spec
    d. Performing Civil Analysis – Slope Analysis, Grading Analysis, Pile length optimization
    e. Access Road and Setbacks
    f. Iterating GCR vs DC Size Options
    g. Generating Shading Scene to import in PVSyst

12. **PVsyst**
    a. Creating Site and Importing Met Data in PVsyst
    b. Soiling and Albedo Estimation
    c. Modeling Racking System in PVsyst
    d. Electrical Design in PVsyst
    e. Bifacial Factors Consideration in PVsyst
    f. Defining Losses in PVsyst -Thermal, Electrical, Module etc
    g. Batch Mode Simulation in PVsyst

13. **Energy Post Processing**
    a. Analyzing PVsyst Report and 8760 Energy Output
    b. Sub Hourly losses/Stow Losses
    c. POI Clipping losses
    d. Effective System Level Degradation of PV Plant
    e. Uncertainty Analysis – P50,P25,P99 etc

14. **Financial(NPV&LCOE) modeling of PV Projects**
    a. Capital and Operational Costs of PV Plants
    b. Revenue Estimation for PV Plant
    c. Tax Incentives – PTC vs ITC
    d. Financial Models
    e. Evaluating different AC:DC ratio, GCR
    f. Capital and Operational Costs of PV Plants
    g. DEVEX and CAPEX (Land, Interconnection, EPC, sales tax, Other)
    h. OPEX (O&M, land leases, property tax, credit costs)
    i. Revenue Estimation for PV Plant
    j. Revenue streams and pricing
    k. Offtake structures
    l. Tax Incentives – PTC vs ITC
    m. IRA rules
    n. Cost of Capital
    o. Financial models (DCF) and benchmarking metrics
    p. Financial impacts of Engineering Optimization

q. Evaluating different AC:DC ratio, GCR, racking (FT vs SAT)
r. Analyzing BESS and gH2 as potential options

15. Project Finance for a PV Project

a. Why finance a project:
b. Renewables projects are capital intensive
c. Introduction to the time-value of money
d. Liquidity – need money on day 0
e. Diversify investments / isolate risks
f. Leverage as a tool to increase equity returns
g. Risks associated with financings
h. Options to finance a project
i. Equity
j. Debt
k. Monetizing Tax Incentives in the US / Tax Equity
f. Overview of a financing process

16. BESS

a. BESS Sizing – MWh/MW
b. Calculating Round Trip Efficiency- DC & AC losses
c. BESS Aux Power
d. BESS Inverter Sizing
e. BESS Augmentation Plan
f. AC/DC Coupling with PV Plant
g. Fire Safety Standards
h. Economic Analysis – I&V

17. Green Hydrogen & LCOH

a. Green Hydrogen Introduction
b. 45V and 3 Pillars of Tax incentives
c. Alkaline vs PEM Electrolyzer
d. Components of a Green Hydrogen Systems
e. Water and Electric Supply Sizing
f. LCOH and Economic Modeling