Teaching Wind Energy Systems

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Introduction

- Agriculture Always Required Energy Inputs
  - Draft Animals and Then Fuels
  - Energy to Manufacture Farm Equipment
- Self Reliance Minimized Inputs
  - Maintenance
  - Repair
  - "Field Engineering"
  - Good with Hands
  - Adapt & Improvise
  - Make Do With What is On-Hand

Agricultural Uses of Wind Energy

- Persia – Vertical Axis Grain Mill ~1100 A.D
- European Horizontal Axis, 4 Blade Grain Mills
- American Wind Machine
  - Pumping Water – 19th Century US Wind Industry
  - Charles Brush Added Generator 1889 in Ohio
- First Propeller 1923 Elkhart IN
- 1925 – 1935 Wind Industry Before Govt.
  - Jacobs Use 3 Blades, Pitch Control & DC Generator
  - Windcharger and Others
- TMEN
  - Re-Emphasized Low Energy Inputs
  - Small & Medium Size Farms

TRENDS

- Wind Farm Energy Mostly to Metro Areas
- Large WECS
  - Variable Speed – "Wild" Frequency
  - Rectifier – Inverters
  - Low Voltage Ride-Through
  - Power Factor Correction in Inverter
- Small to Medium WECS
  - Fixed Pitch
  - DDPMM – Permanent Magnet Machines
    - Rare Earth Magnets – Highest Magnetic Flux
    - Direct Drive Eliminates Gears, Belts or Chains
  - Transformerless Inverters

West Texas A & M University

- Alternate Energy Institute

The Grid

- Deregulation Increased Complexity
- US Grid
  - Eastern Area
  - Western Area
  - ERCOT – Texas Grid
- Power Flows by Laws of Physics
  - Like Water Taking Path of Least Resistance

The Smart Grid

- "Technological Achievement of the 21st Century"
- Using Internet for Telemetry & Control
  - Higher Data Rates
  - Security Risks
- Utilities Always Used 2 Way Communication

Topics Covered in ELMT 1402 Solar Photovoltaic Systems

- Connectors, Wiring and Wring Devices
- Fuses and Circuit Breakers
- System Loads and Energy Budget
- Batteries, Battery Charge Regulators & DC Systems
- Static Inverters
- Grounding
- National Electric Code

TCC Renewable Energy Program

- Insert
  - RE AA Curriculum – Tightly Integrated
    - Prerequisites
      - Trigonometry & College Algebra
      - Basic Computer Skills
    - Specific Order for Optimal Learning
    - Labs
  - RE Certificate – For Those With
    - Other Degrees
    - Experience

WIND 2459 LECTURE OUTLINE

- Introduction
- History of Wind Energy
- Energy & Power Review – High Entropy Power
- Basics of Wind Energy and 3 Phase Power
- Properties of Wind
- Wind Resource Assessment
- Estimating Output
- Financial Modeling of Wind Projects
- Aerodynamics of Wind Turbine Blades
- Wind Energy Conversion System Components
- Electricity & Generators
- Connecting Wind Turbines to the Grid
- Environmental Impacts

WIND 2459 Course Notes Introduction

- Technical Course
- Last Semester of 4 Semester Associates Program
- Uses Algebra, Vectors, Geometry and Trigonometry
- Includes Current Industry News & Topics
- Hands on Lab Exercises
- Uses ALL of Your Previous Electronics

Lab Volt-Trainer

Used for Weekly Labs & Projects – Improvements & Modifications

DIY vs. Turnkey

- The Electric Code is Your Friend!
- Engineered Components or Kits
- Science & Vo-Tech Projects

DC vs. AC – An Old Debate

- Many 12 VDC Appliances are Available
- Excessive Copper Required for 12 VDC Systems
- Low Voltage DC → Very Low Shock Hazard
- DC Eliminates Multiple Stages of Conversion
- AC Appliances Standard

Standalone vs. Grid-Connected Battery Storage vs. Non-Storage

- Some Inverters Will Not Operate Stand-Alone
- Battery Storage is Required for Stand-Alone
- The Ability to Operate Stand-Alone With Storage is Recommended for Rural Areas

Conclusion

- Technology
  - The Fundamentals Were Done in the 1930's
  - Power Electronics Makes AC Easy
    - Microcontrollers Delay Obsolescence
      - Firmware updates replace mistakes & add Features
      - Contol Hardware Updates using the Same Power Elec.
  - DDPMG reduces
    - Uptower Weight without Gears, Chains or Belts
    - Reduces Major Mantenace
- The Best Choice Is the One You Put Up & Use!

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