Wind Generation

Infrastructure Case Study

Agenda

- Alliant Energy Portfolio Mix
- Wind Generation Across the United States
- Wind Turbine Generator (WTG) Operation
- Overview of Balance of Plant (BOP) Equipment
- Wind Development & Construction Activities
- Infrastructure Challenges / Case Study

Alliant Energy - LNT

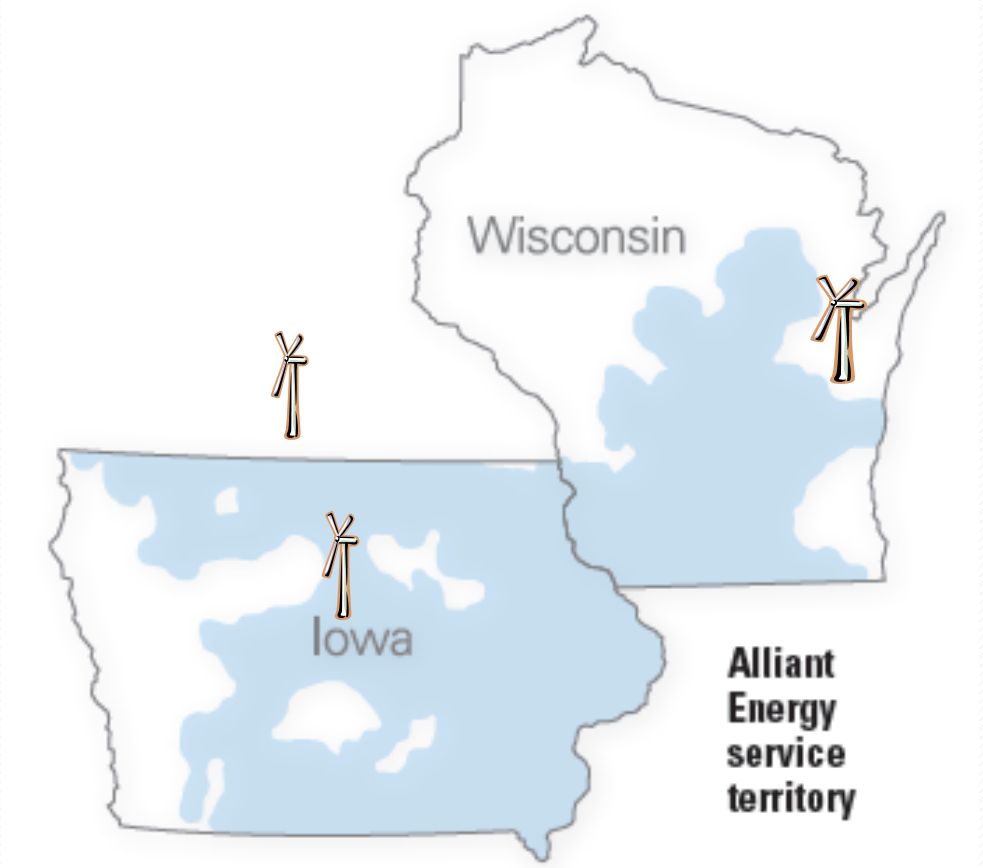
We are an investor owned energy-services provider:

- IPL – Interstate Power & Light Co
- WPL – Wisconsin Power & Light Co

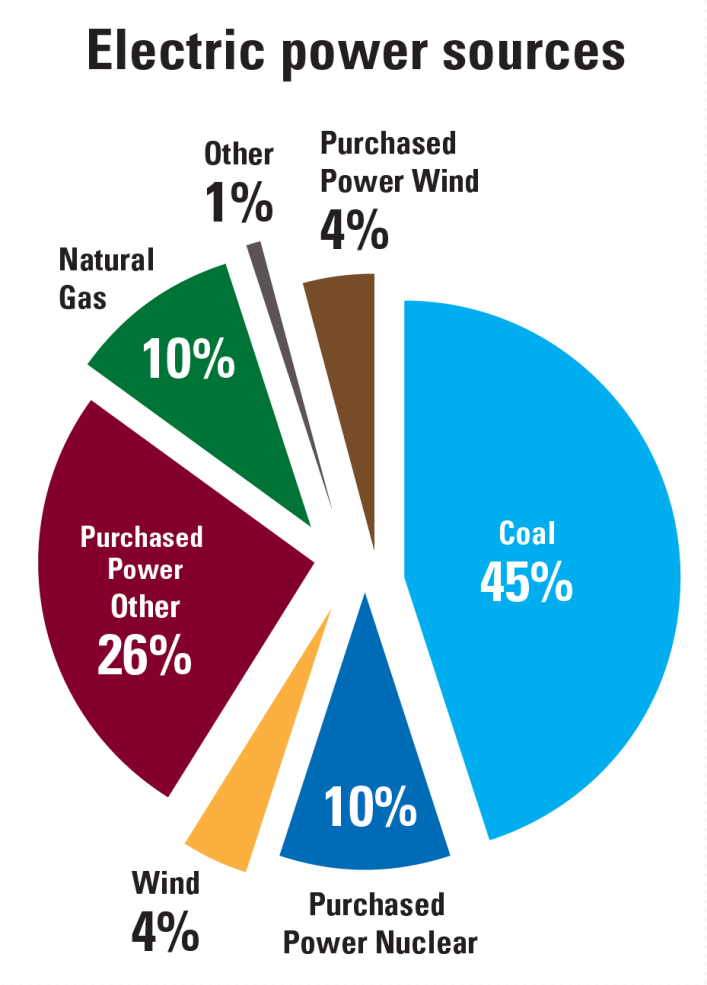
- Headquartered in Madison, WI
  - General Offices in Cedar Rapids & Dubuque, IA
  - ~ 4000 Employees

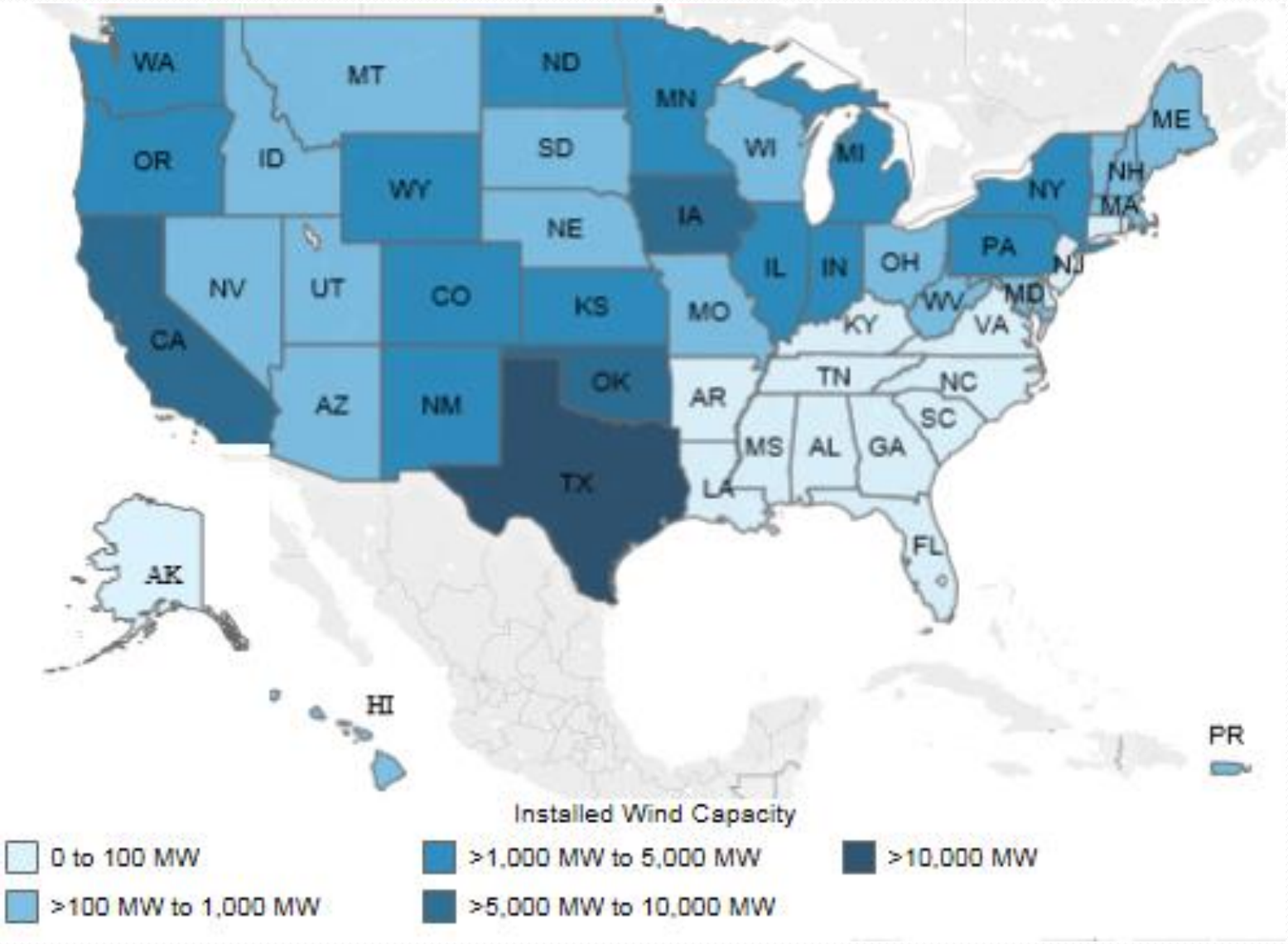
Alliant Energy – Service Territory

- Alliant Energy serves over 1,000 cities & towns
- Customers:
  - > 950,000 electric
  - > 420,000 natural gas

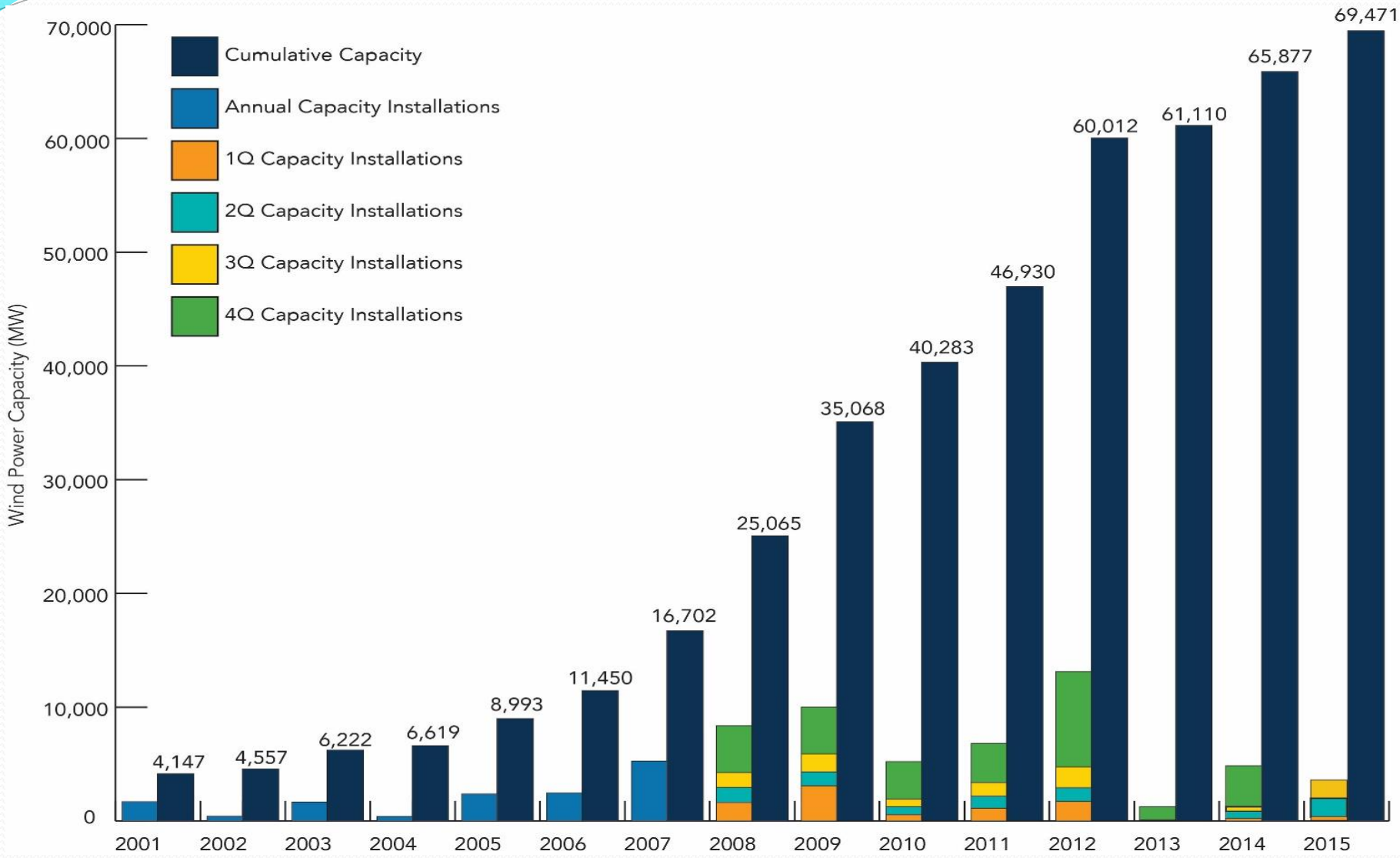


Energy Portfolio 2014





Source: AWEA 2016



Graph Source: AWEA Q4 2015 Market Report

Wind Generation Benefits

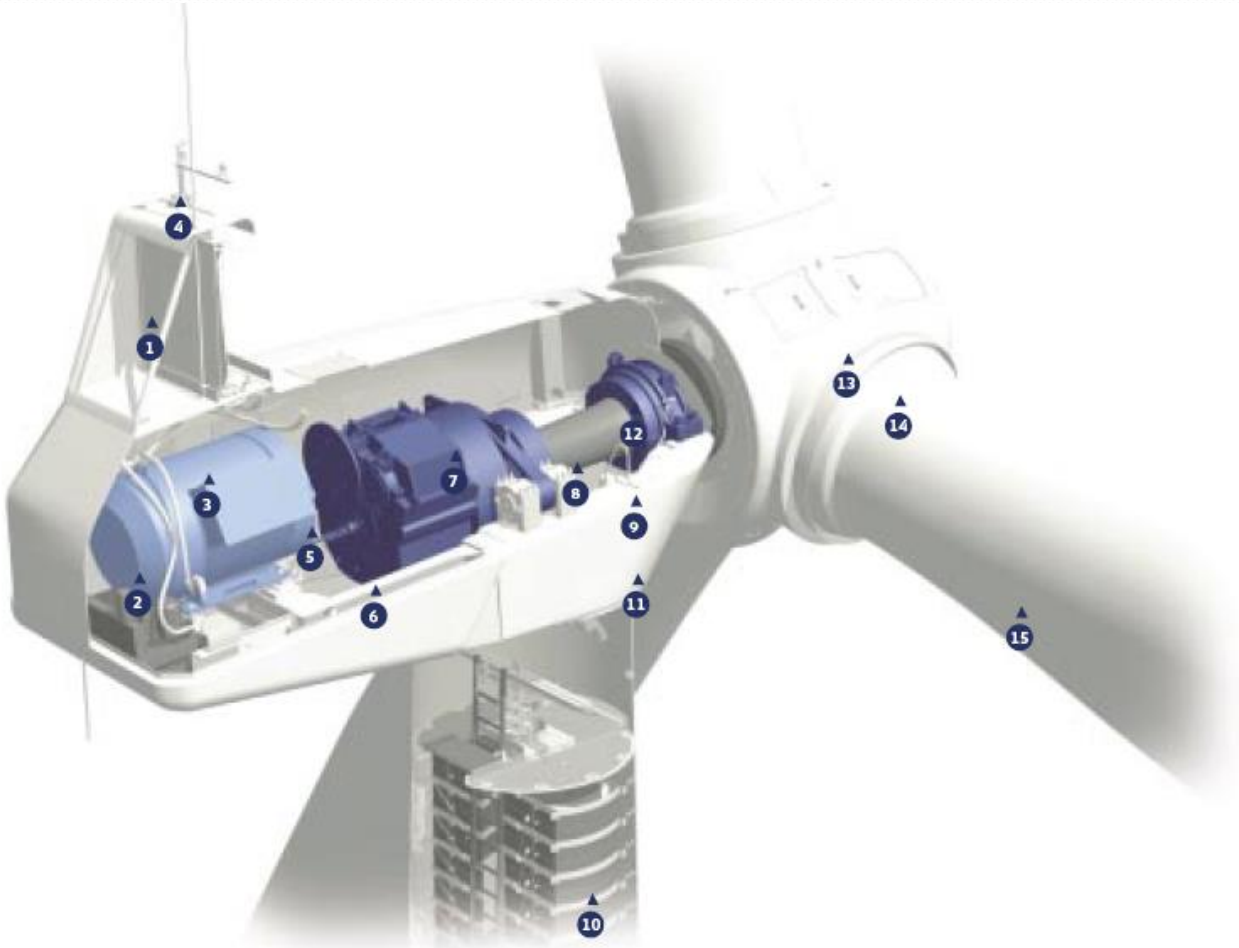
- Benefit to customers, our communities and the state
- Wind turbines generate clean, cost-effective energy for customers
- Create tax revenue for communities, and bring construction jobs and economic growth to the state.
- Wind Technician – Fastest growing profession in the U.S.
- Low Cost Energy
  - Renewable Energy Tax Credits = Direct Benefit to the Customer
  - Zero Fuel Cost
- “Wind Farmers” – Economic Support to Rural Communities
  - Turbine & Miscellaneous Easement Payments

Wind Generation Portfolio

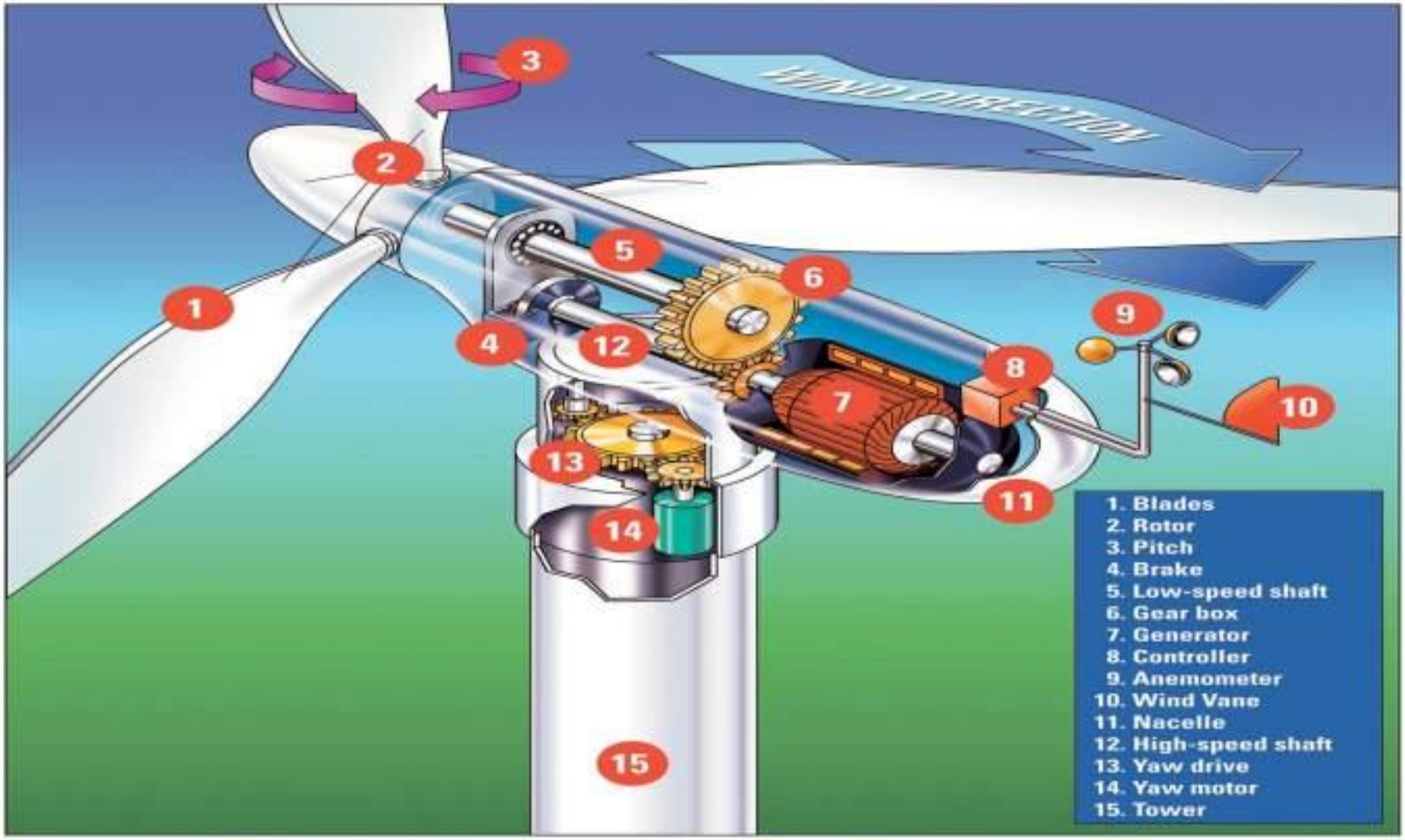
- 344 Vestas V82 Turbines
  - 1.65 MW Generator Rating
  - 568 MW Fleet
- Cedar Ridge – Eden, WI
  - 41 Turbines / 68 MW
- Bent Tree – Hartland, MN
  - 122 Turbines / 201 MW
- Whispering Willow – Iowa Falls
  - 121 Turbines / 200 MW
- Franklin County – Iowa Falls
  - 60 Turbines / 99 MW

Wind Turbine Generator - WTG

1. Heat Exchanger
2. Generator
3. Nacelle Controller
4. Anemometer Wind Vanes
5. High Speed Coupling
6. Mechanical Brake
7. Gearbox
8. Main Shaft
9. Yaw Motor & Planetary
10. Tower Damper
11. Bed Plate Frame
12. Main Bearing
13. Hub
14. Pitch System
15. Blade



Additional WTG Components



Vestas V82 Stats

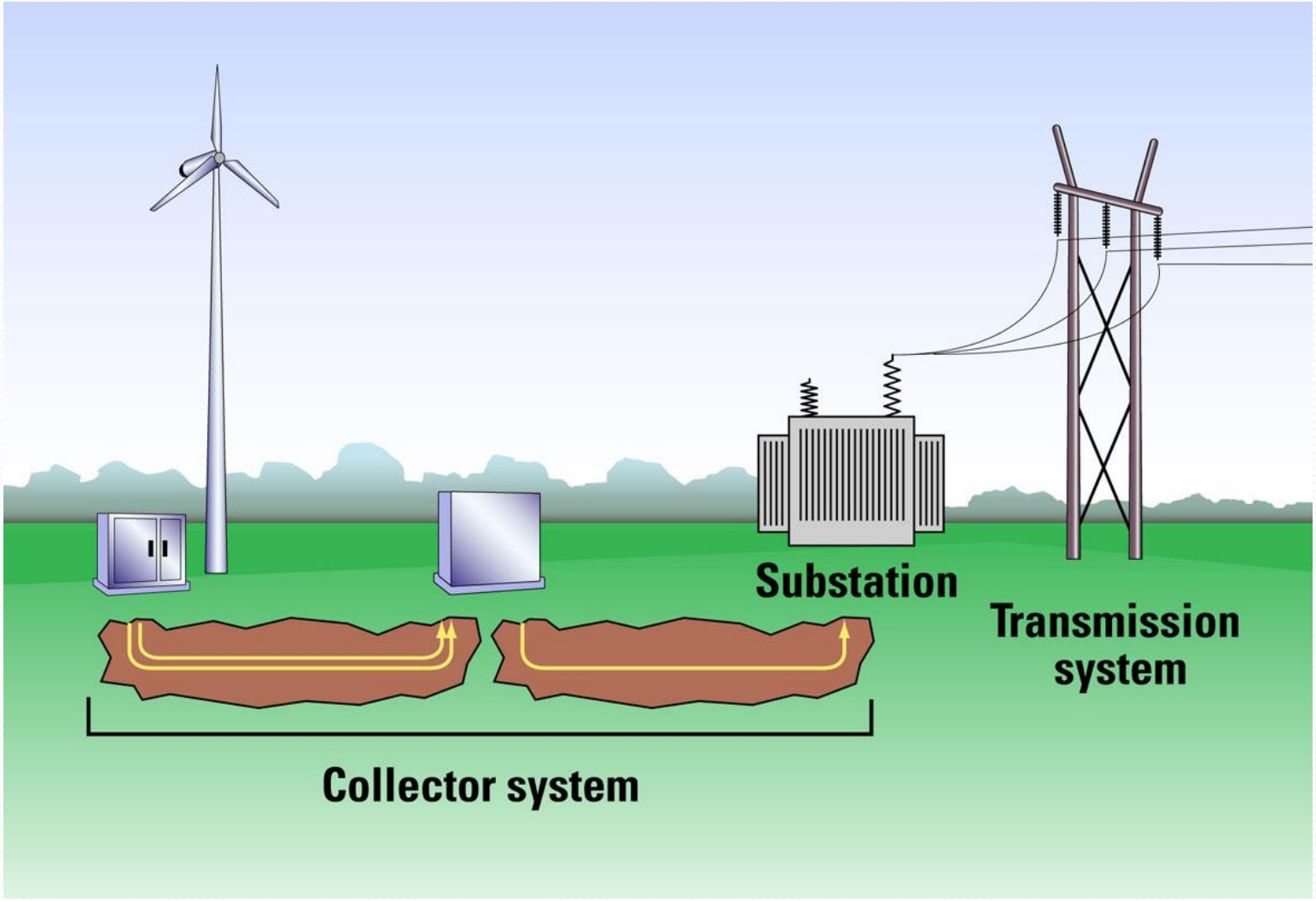
- Power Output 1.65MW
- Hub Height 265 feet
- Top of blade travel 400 feet
- Blade length 131 feet
- Blade weight 15,000 lbs.
- Nacelle weight 104,000 lbs.
- Nacelle size Class A Motorhome
- Foundations 515 yards of concrete

- 57 Cement Truck Loads per Turbine
- 7,000 Cement Truck Loads Total Project
- 45’ X 45’ X 8’ Foundation

Turbine Performance Stats

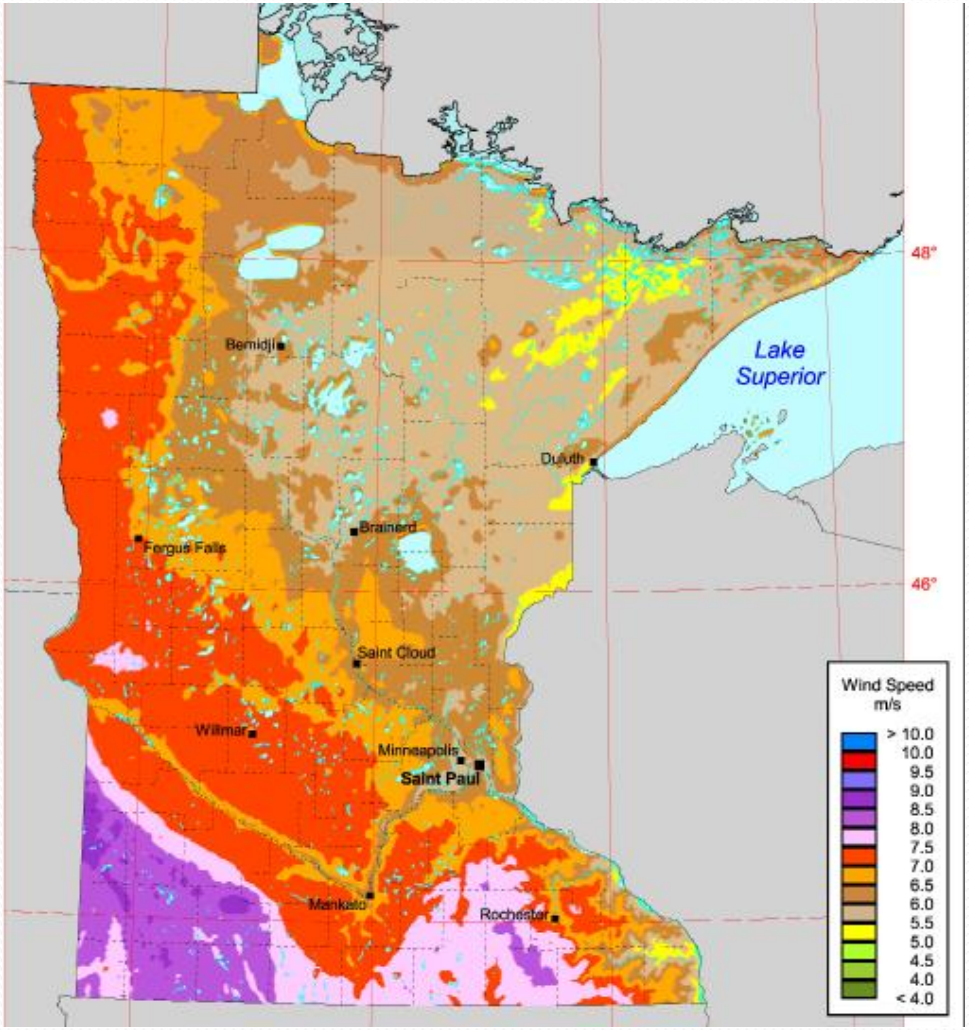
• Cut in speed	8	mph
• Max Output	25	mph
• Cut out	45	mph
• Rotor RPM	14	rpm
• Tip speed	138	mph

Balance of Plant - BOP

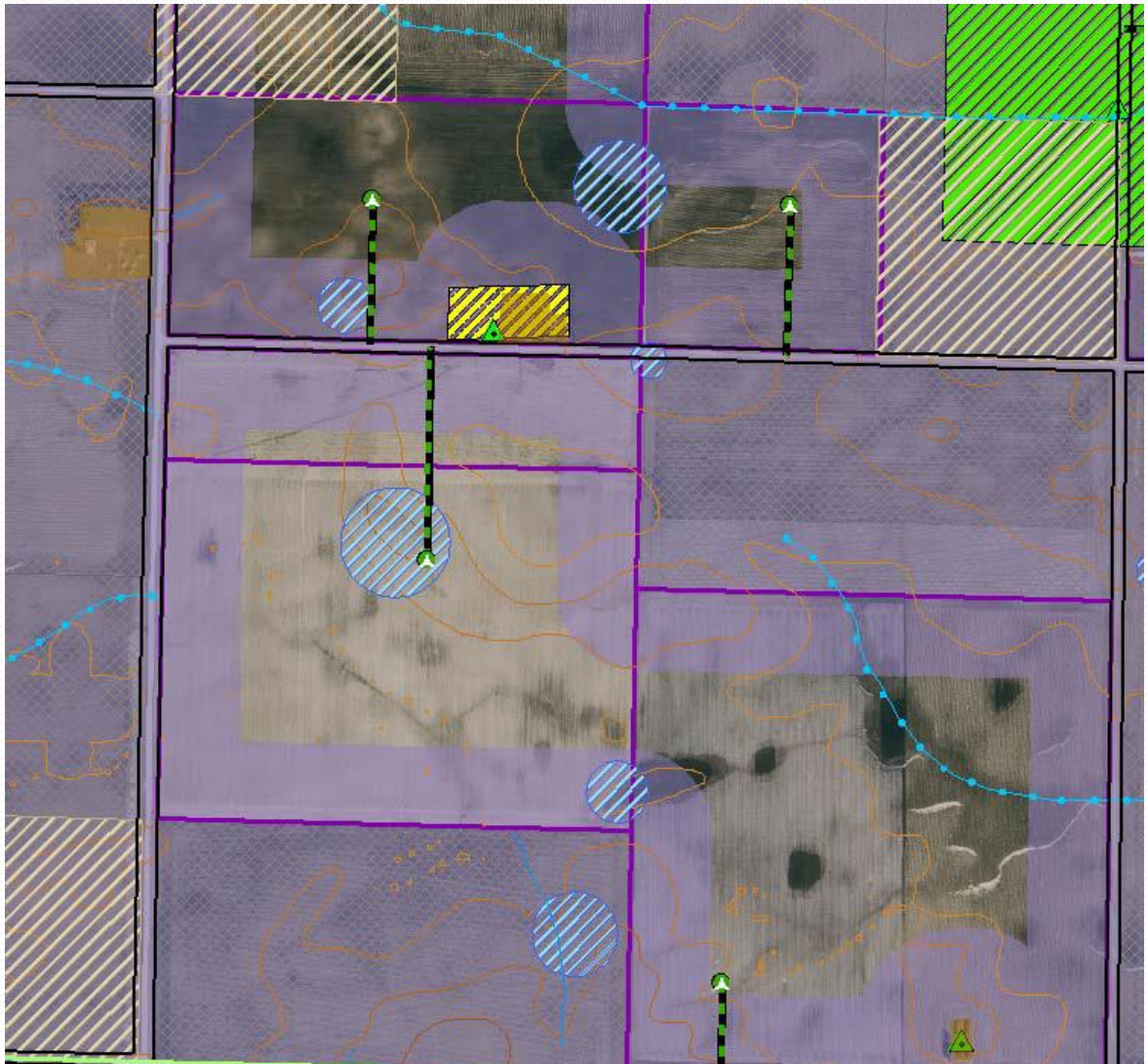


Wind Development

- Meteorological Data
- Infrastructure Consideration
  - Road Access, Grid Location
- Land Rights
- Easements
  - WTG, Roads, Collector
- Regulatory Approvals
- Generator Interconnection
- Geotechnical Analysis
- Micro-Siting
  - Setbacks



Geographic Information System & Micro-Siting



Turbine Layout

Access Roads

16 feet wide permanent

35 feet wide for cranes

Tower, Nacelle, Blade

Construction Overview

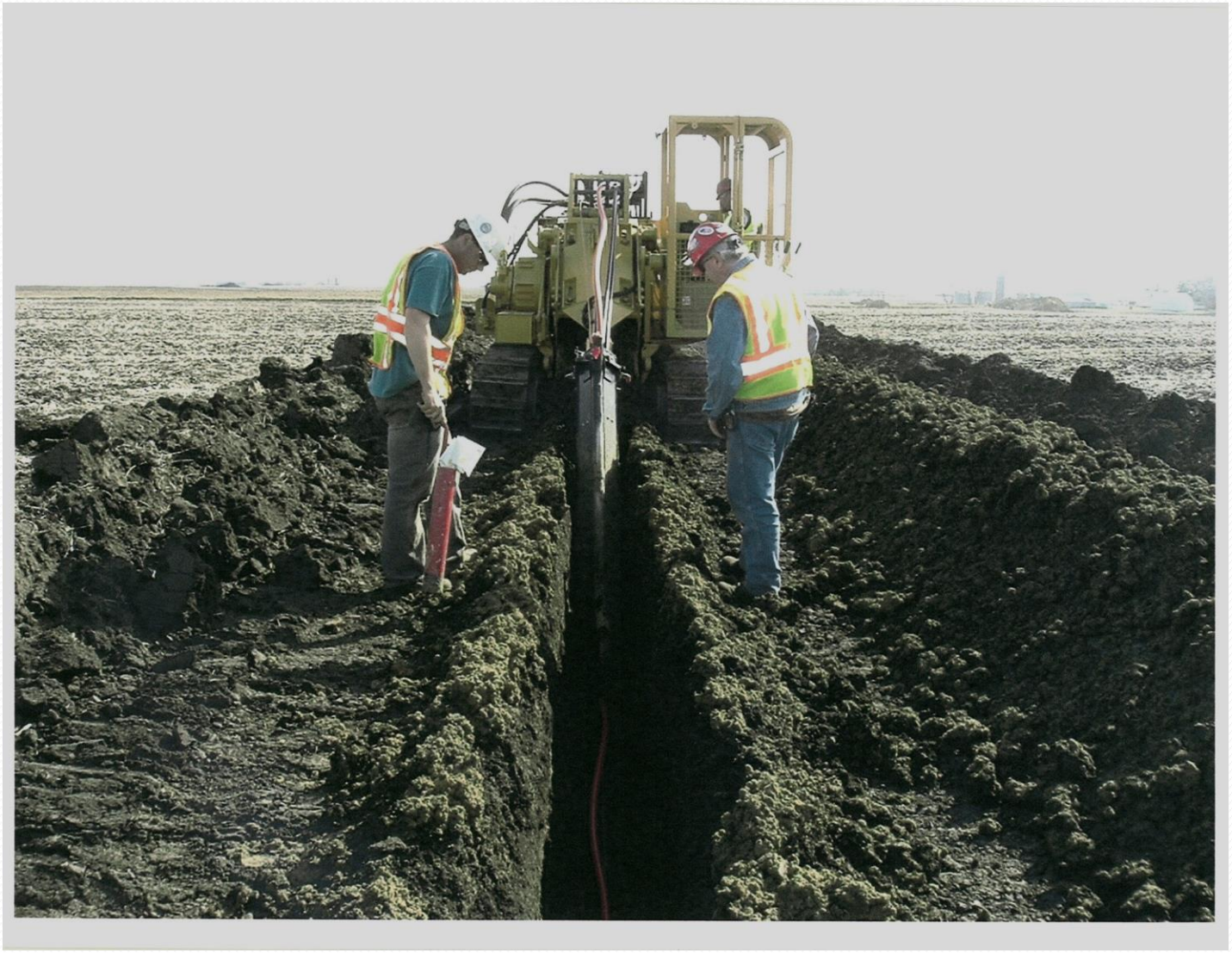
Geotechnical – Foundation Work

Completed Foundation

Tower Assembly

“Flying the Rotor”

Installation of Collector Lines



Substation

- Receives 34.5kV Power generated by the WTG
- Main Power Transformer / GSU (Generator Step Up) steps up the power to 161kV for interconnection to the transmission system
- Reactive Power (VAR) Control
  - Capacitor Banks
  - Dynamic Volt-Amp Reactive Control (D-VAR)

Infrastructure Challenges / Case Study

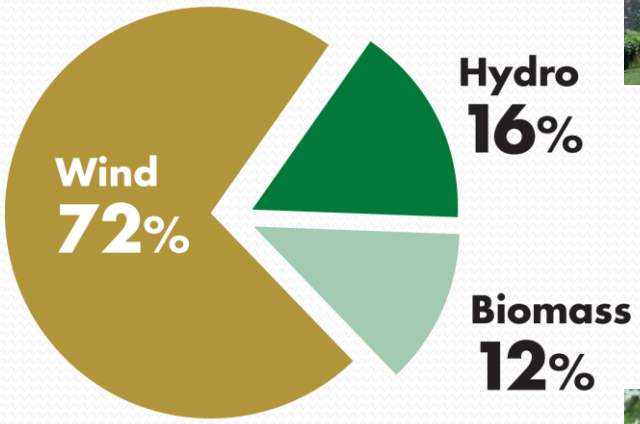
- Rural Areas
  - Siting
    - Turbine Rating / Size / FAA Ceiling
  - Project Cost Cap Pressure
    - Road Construction
    - Distribution / Transmission Build out to get to the Grid
  - Transmission Constraints / Congestion
    - Localized, Network, Time of Year Challenges
    - Transmission Upgrades
    - MVP – Multi Value Projects
  - Voltage and Frequency Control
  - Limiting Component / Repowering / Recycling / Cost Reduction

Questions

Appendix

A Leader in Renewable Energy

Renewable Energy Sources Used



Source: Alliant Energy records of consumption in MWh.

Cedar Ridge Wind Farm

- 41 turbines - Vestas V-82
- 68 Megawatts
- 4th largest wind farm in Wisconsin
- Displaces approximately 75 rail cars of coal per month
- $180M capital investment

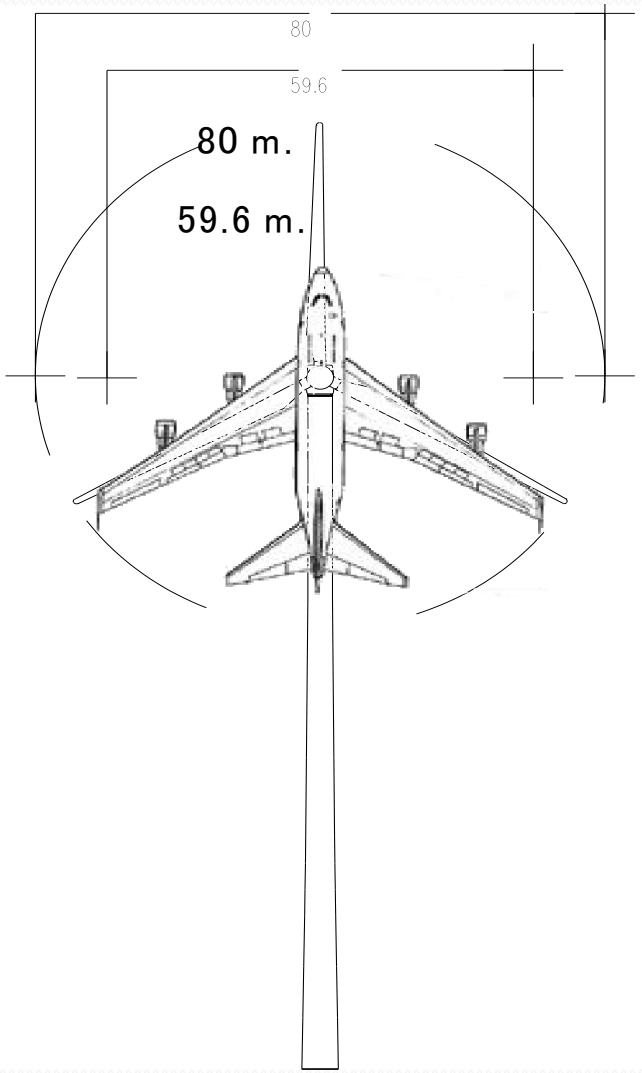
Bent Tree Wind Farm

- 122 turbines -Vestas V-82
- 201 Megawatts
- 5th Largest Wind Farm in MN
- Displaces approximately 225 rail cars of coal per month.
- $440M capital investment

Whispering Willow East

- 121 turbines -Vestas V-82
- 200 Megawatts
- Displaces approximately 225 Rail Cars of coal per month
- $460M capital investment

How Big is a Vestas V82 Turbine?



Vestas V82 – 80M Turbine

Superimposed on a Boeing 747 jumbo jet


3 10:17 AM

Dimensions

How much Power?

Each Turbine produces 2,200 Horsepower at 25 mph wind speed

Wind Turbine Generator Maintenance

- Routine Preventative Maintenance Services
  - Change filters, Greasing & Lubrication, Oil Changes
  - Torque Bolts
  - Inspections
- Breakdown Repair
  - Troubleshoot Systems & Restart Turbines
  - Corrective Maintenance – Replace Parts
- Underground Electrical System / Substation
- Major Component Repair / Replacement
  - Main Bearings, Gear Boxes, Generators

Wind Turbine Generator Vs. Windmill

- Windmills have flat blades which convert wind energy directly into mechanical energy for tasks such as milling grain or pumping water.
- Wind Turbines have blades shaped like a wing which capture energy and convert it to electricity.
- A Windmill can capture about 5% of the wind's energy whereas a Wind Turbine captures and converts about 40% of the wind's energy.