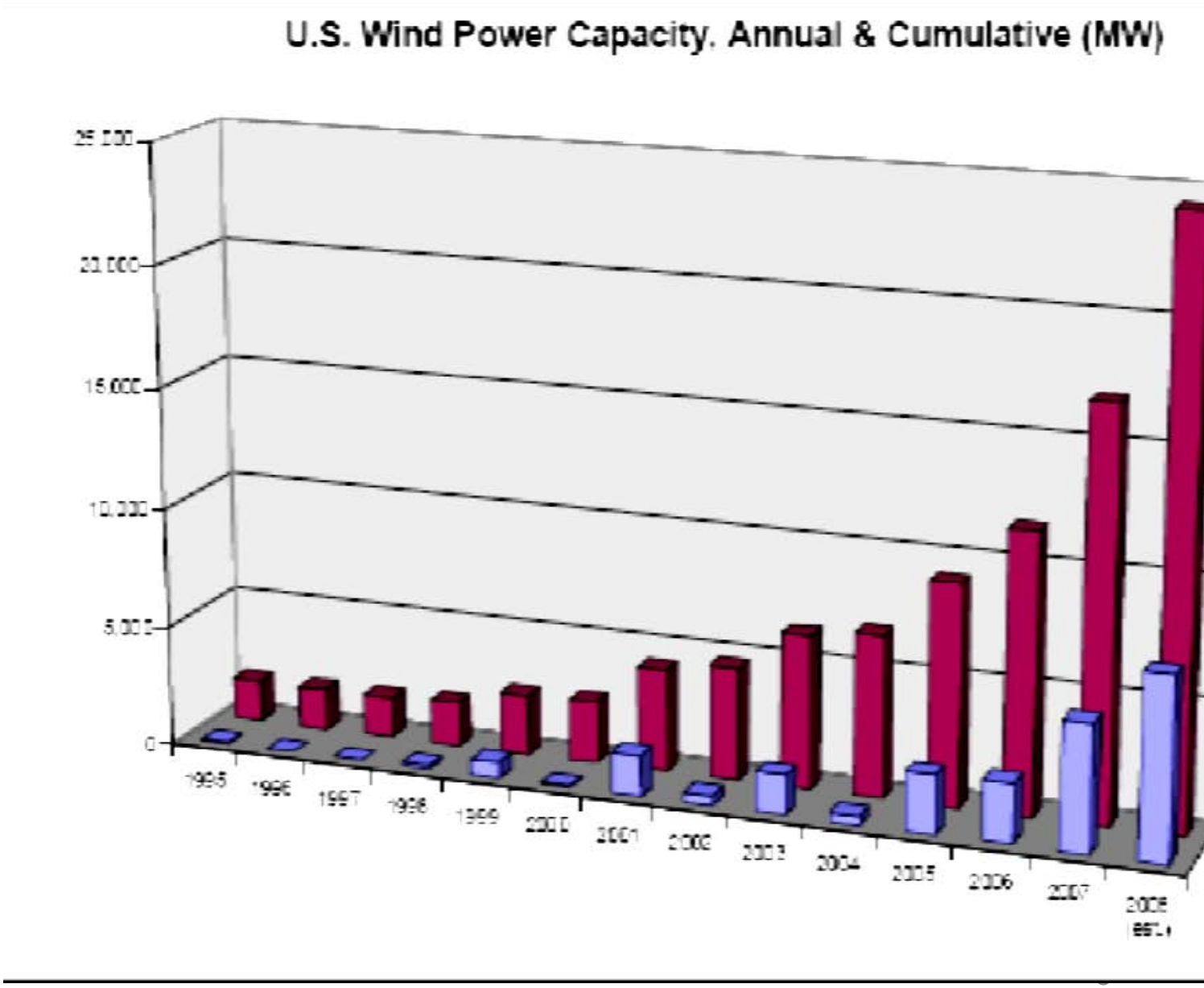
Tribal Development of Wind Energy

Disclaimer

- **The information provided is for informational purposes only, does not constitute legal advice or create an attorney-client relationship, and may not apply to all circumstances. If legal advice or other expert assistance is required, the services of a competent professional person should be sought.**

Growth and Size of the Wind Energy Industry in the U.S.

- **Windpower Is Big Business**
- U.S. now leads world in installed capacity
- Installed capacity increased by 50% in 2008
- Capacity installed in 2007 and 2008 doubled all preceding capacity installation
- 2008 capacity installed represented 42% of all new power capacity installed


U.S. Wind Power Capacity. Annual & Cumulative (MW)
25,000
20,000
15,000
10,000
5,000
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008

THE TOP TWENTY STATES for wind energy potential, as measured by annual energy potential in the billions of kWhs, factoring in environmental and land use exclusions for wind class of 3 and higher.

1	North Dakota	1,210	11	Colorado	481
2	Texas	1,190	12	New Mexico	435
3	Kansas	1,070	13	Idaho	73
4	South Dakota	1,030	14	Michigan	65
5	Montana	1,020	15	New York	62
6	Nebraska	868	16	Illinois	61
7	Wyoming	747	17	California	59
8	Oklahoma	725	18	Wisconsin	58
9	Minnesota	657	19	Maine	56
10	Iowa	551	20	Missouri	52

Source: *An Assessment of the Available Windy Land Area and Wind Energy Potential in the Contiguous United States, Pacific Northwest Laboratory, 1991.*

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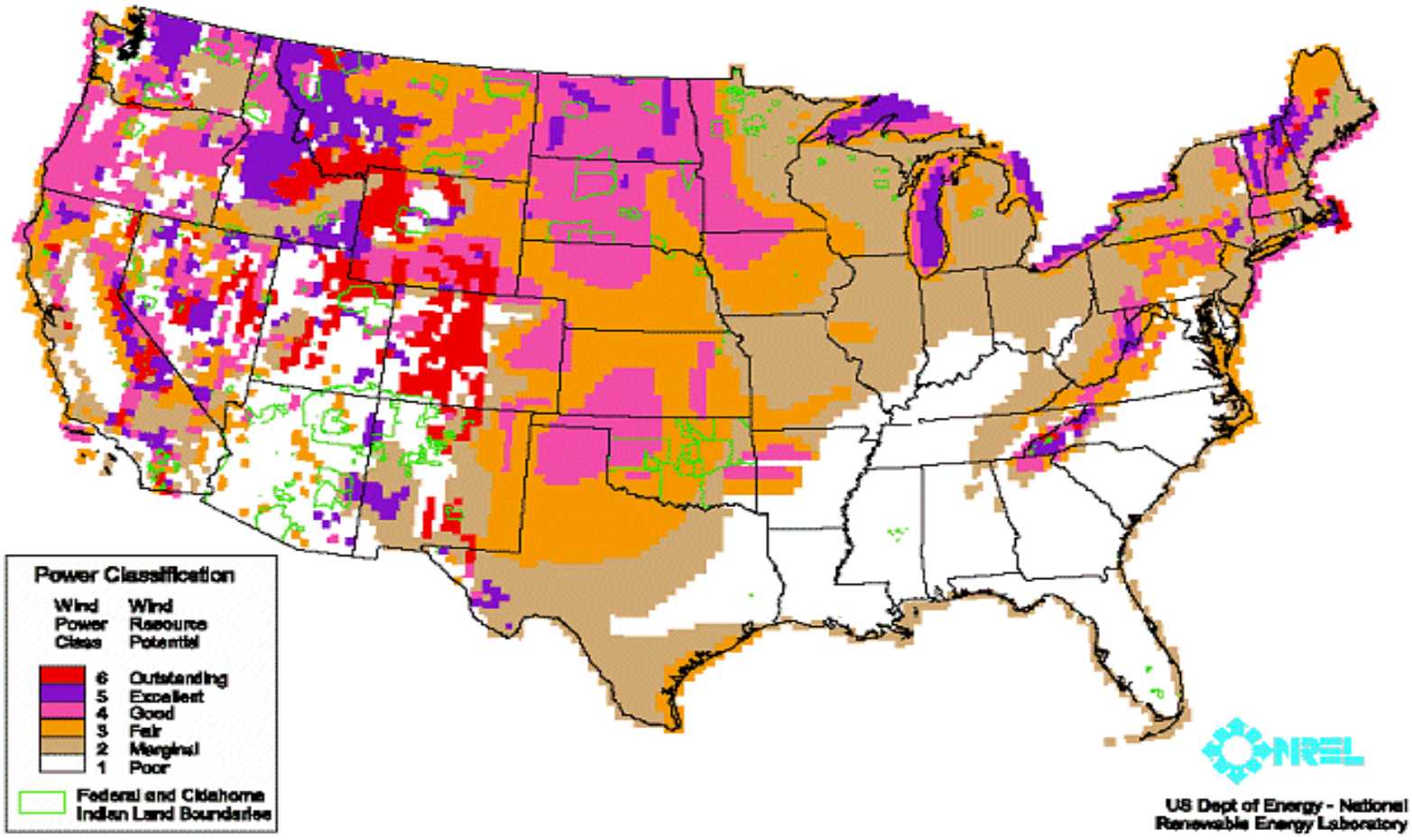
Figure 13. Wind Resource Potential



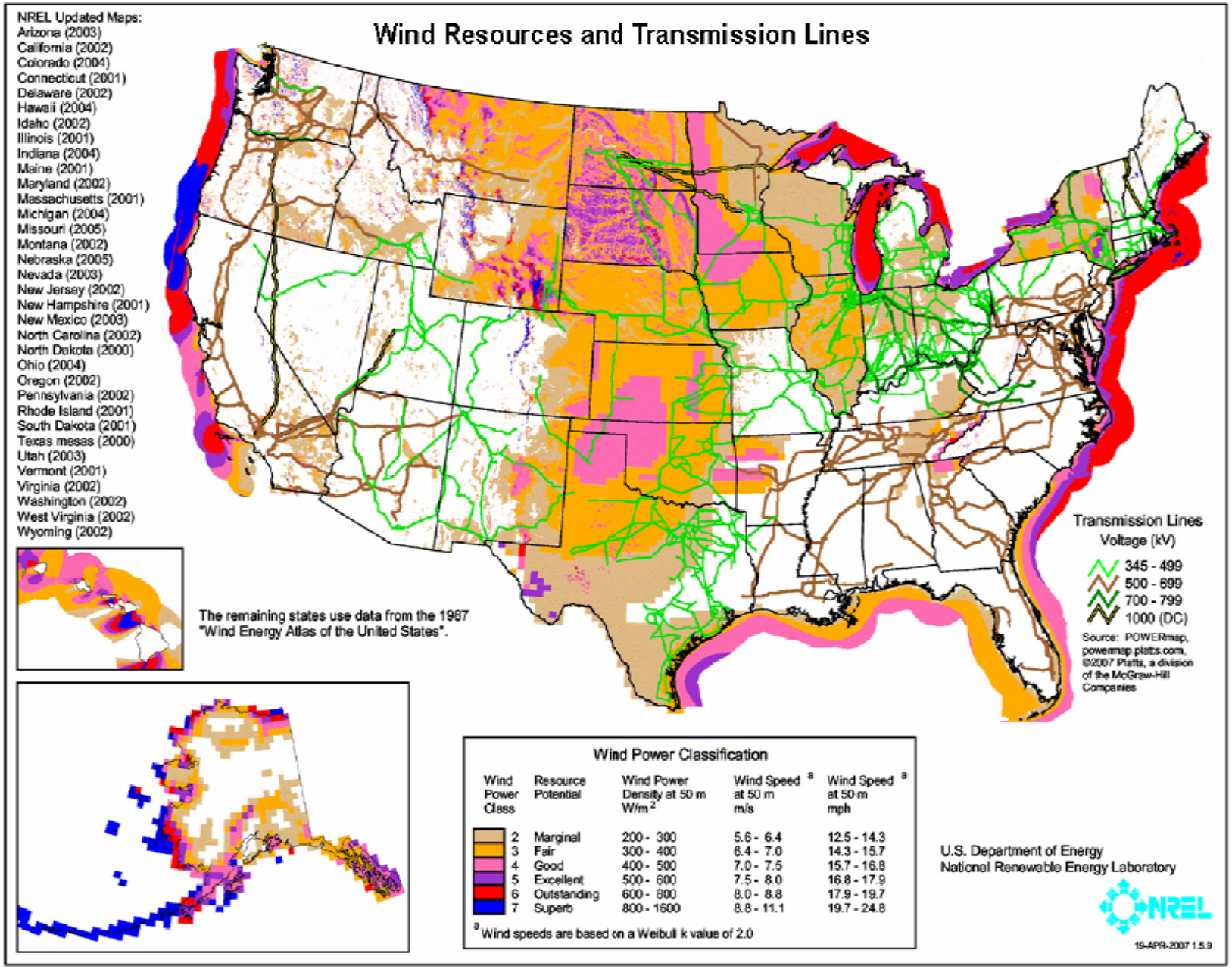

Wind Resources and Transmission Lines
NREL Updated Maps:
Arizona (2003)
California (2002)
Colorado (2004)
Connecticut (2001)
Delaware (2002)
Hawaii (2004)
Idaho (2002)
Illinois (2001)
Indiana (2004)
Maine (2001)
Maryland (2002)
Massachusetts (2001)
Michigan (2004)
Missouri (2005)
Montana (2002)
Nebraska (2005)
Nevada (2003)
New Jersey (2002)
New Hampshire (2001)
New Mexico (2003)
North Carolina (2002)
North Dakota (2000)
Ohio (2004)
Oregon (2002)
Pennsylvania (2002)
Rhode Island (2001)
South Dakota (2001)
Texas mesas (2000)
Utah (2003)
Vermont (2001)
Virginia (2002)
Washington (2002)
West Virginia (2002)
Wyoming (2002)
The remaining states use data from the 1987 "Wind Energy Atlas of the United States".
Transmission Lines
Voltage (kV)
345 - 499
500 - 699
700 - 799
1000 (DC)
Source: POWERmap, powermap.platts.com, ©2007 Platts, a division of the McGraw-Hill Companies
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m2
Wind Speed a at 50 m m/s
Wind Speed a at 50 m mph
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb 800 - 1600 8.8 - 11.1 19.7 - 24.8
a Wind speeds are based on a Weibull k value of 2.0
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
19-APR-2007 1.5.9

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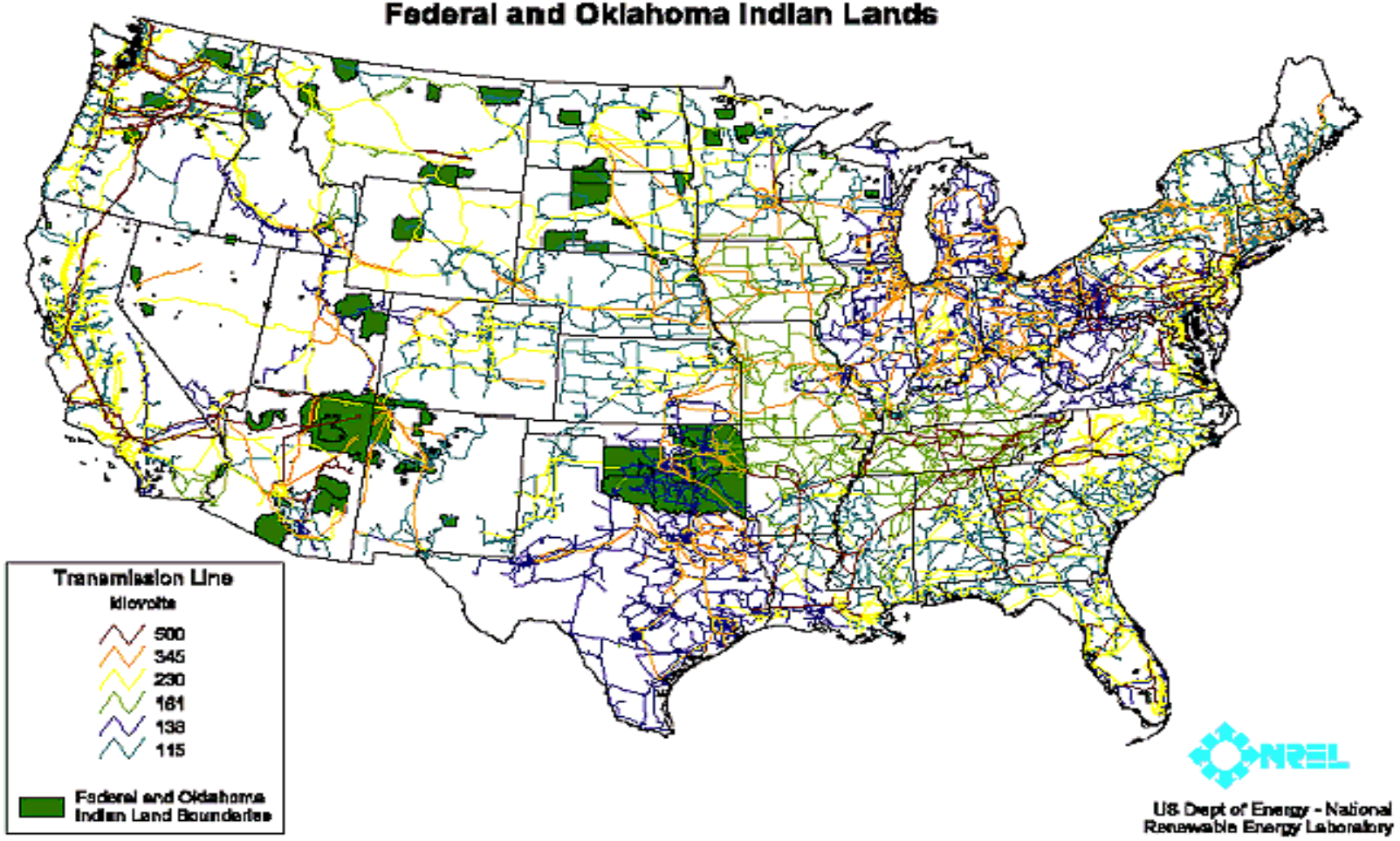
Figure 16. Transmission Lines with Federal and Oklahoma Indian Lands



Who's Who – Wind Development Value Chain

DEVELOPERS
- FPLE
- Iberdrola
- Acciona
- AES
- BP Alternative
- Babcock & Brown
- Invenergy
- Horizon/EDP
- Shell

POWER PURCHASERS
- AEP
- PacifiCorp
- Exelon
- Xcel
- LADWP
- PSE
- Reliant

EQUIPMENT MANUFACTURERS
- GE
- Vestas
- Gamesa
- Siemens
- Clipper
- Suzlon
- Mitsubishi

PROJECT FINANCIERS
- Fortis
- Bayerische Landesbank
- Dexia
- Manulife
- Prudential
- JP Morgan
- GE Financial Services

EQUITY INVESTORS
- JP Morgan
- Babcock & Brown
- FPL Energy
- Edison Mission
- Meridian

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Wind Energy Industry Challenges

- **THE ECONOMY**
- historical low price of oil and gas
- capital lock
- Production Tax Credit ("PTC") provides no advantage
- **Lack of U.S. Supply Chain**
- on-again, off-again nature of wind resource, renewable energy interest
- **Transmission Constraints**
- wind resources tend to be in areas far from population concentrations and transmission capacity or access

Production Tax Credit (IRC Section 45)

- Investor must need tax credits.
- Applies to qualifying renewable energy facilities placed in service by specific deadlines.
- Production Tax Credit would provide a tax credit of 1.8 cents per kWh produced over ten (10) years.
- For example, a large 40 MW project operating at 30% capacity would be expected to spin off ~ $2,000,000 per year in production tax credits.

PTC Limitations

- In order to claim the PTC, the taxpayer must own the facility and produce the electricity
- The party claiming the credit must receive the same proportion of gross revenues and PTCs from the project
- PTCs cannot be stripped and sold separately
- Other limitations (reduced by federal, state and local credits and grants related to construction of the facility, offsets limits to other taxes, subject to passive loss rules)

Value Components

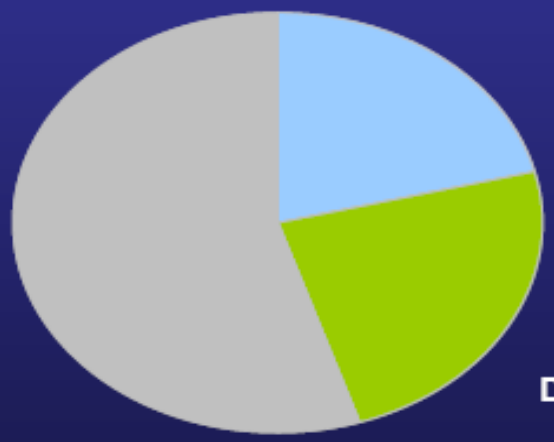
% NPV Value of Equity Cash Flows

Production Tax Credit (21%)

- Requires tax appetite
- 10-year term

Energy Revenue (55%)

- 20-year term



Depreciation (24%)

- Requires tax appetite
- Predominantly 5-year term

Major Assumptions: a) 37% Net Capacity Factor
b) PPA = 5.5 cents/kWh
c) 200 MW project with $1.77 million/MW total cost

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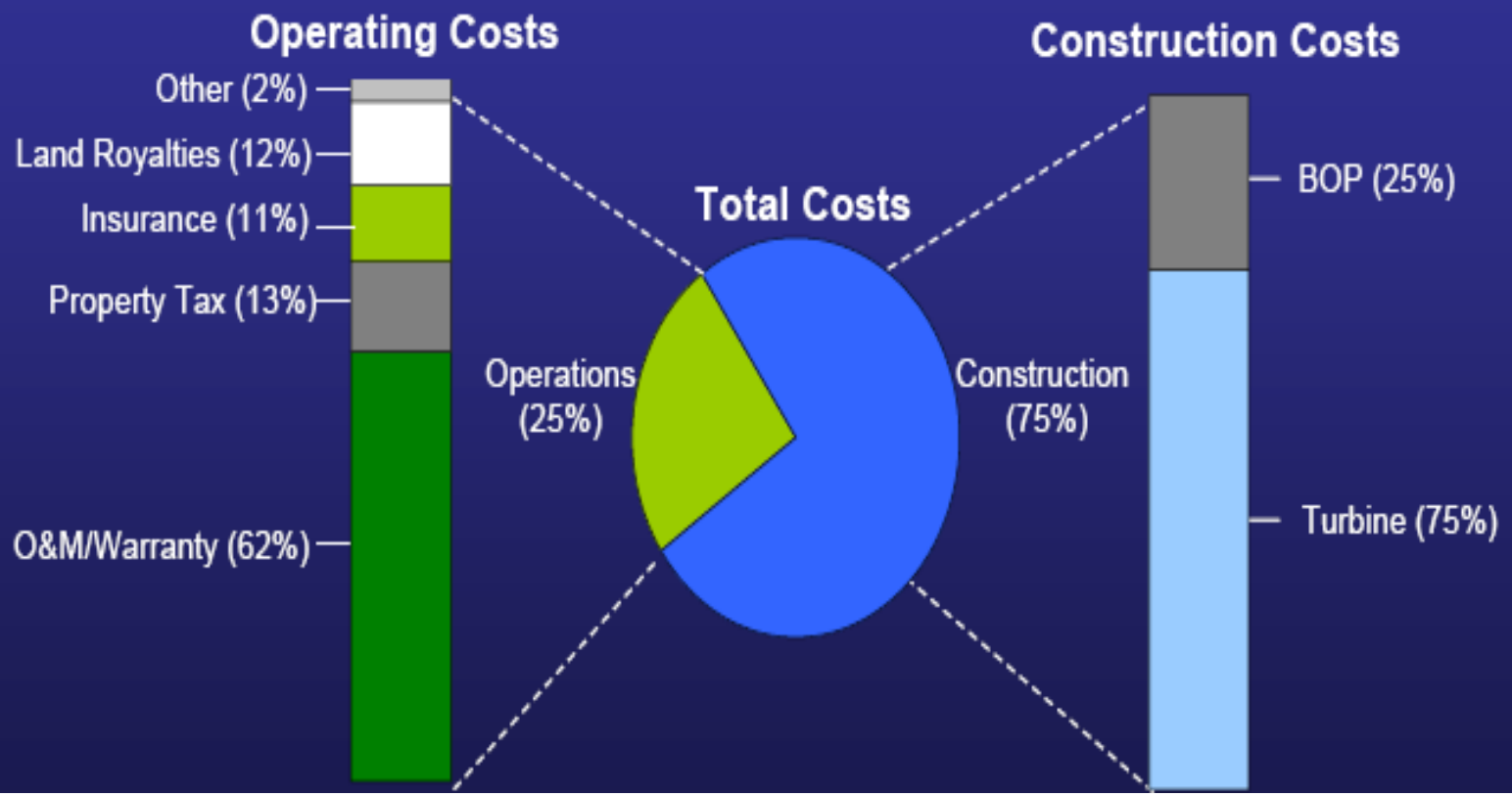
Cost Components



Key Difficulties for Windpower

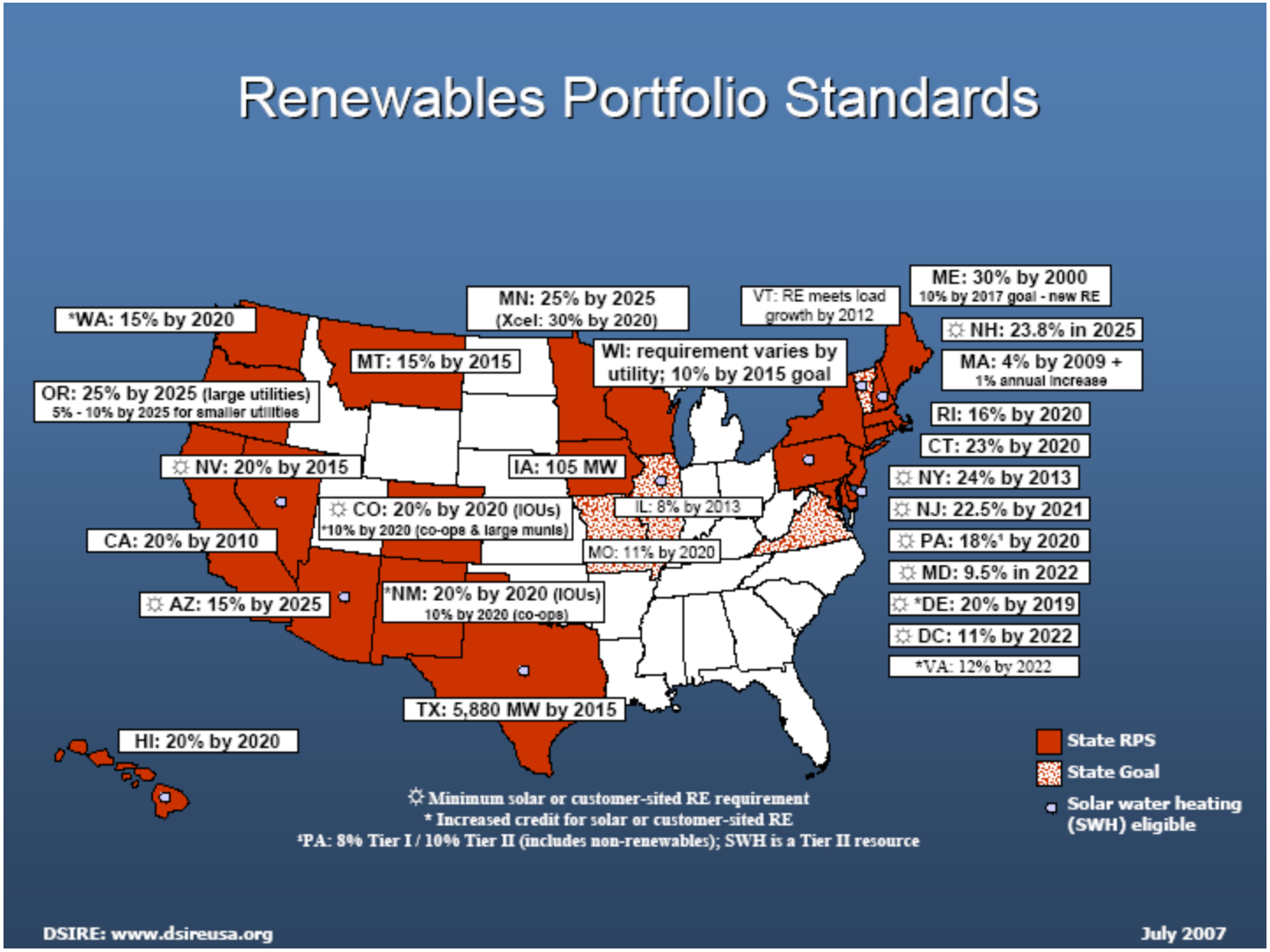
- **Policy Uncertainty**
- **Siting and Permitting**: ownership of land; avian, wildlife, noise, visual, other environmental impacts; airspace/military/radar impacts; radio and television signal interference
- **Operational impacts**: intermittency of wind resource, ancillary services, allocation of costs
- **Transmission**: FERC rules, access, Regional Transmission Organizations ("RTO") formation, may need new lines
- **Accounting for non-monetary, new value difficult**: green power, no fuel lines price risk, reduced emissions
- **NIMBY** – Not In My Back Yard

*Source NREL

Wind Industry Advantages

- PTC extension plus Investment Tax Credit
- Carbon developments (fluctuating cost of fossil fuels, non-renewable)
- Renewable Energy Portfolio Standards (“RPS” or “RES”)
- Renewable Energy Credits (“RECs”)
- Transmission legislation
- Other incentives for enhancement of renewable energy supply chain
- Technological advances

Renewables Portfolio Standards



Colorado's Commitment to Renewable Energy

- Colorado is committed to energy efficiency and integrating renewable energy into its energy portfolio. Colorado's strategic location makes it a prime candidate for using a variety of renewable energy sources – solar, wind, geothermal, biomass, and hydropower. Colorado is working hard to make energy efficiency and the use of renewable energy technically, economically and institutionally sustainable.

Colorado's Commitment to Energy Efficiency

- Energy efficiency, including weatherization, is a critical part of reducing our non-renewable energy dependence. The Governor's Energy Office partners with fourteen pre-qualified Energy Service Companies to offer Performance Contracting Services to program participants to improve energy efficiency by funding capital building improvements through future energy and maintenance cost savings. Tribal entities in the State are eligible to apply to this program.

Colorado Renewable Energy Standards

- **Investor-Owned Utilities**
- 5% of its retail electricity sales in Colorado each year for the years 2008-2010;
- 12% of its retail electricity sales in Colorado each year for the years 2011-2014;
- 20% for 2015-2019; and
- 30% of its retail electricity sales in Colorado for the year 2020 and for each following year.

Colorado Renewable Energy Standards

- **Cooperatives and Municipal Utilities serving more than 40,000 customers**
- 1% of its retail electricity sales in Colorado each year for the years 2008-2010;
- 3% for 2011-2014;
- 6% for 2015-2019; and
- 10% of its retail electricity sales in Colorado for the year 2020 and each following year.

Environmental Benefits

- No Sulphur Oxides (“Sox”) or Nitrogen Oxides (“NOx”)
- No Particulates
- No Mercury
- No Carbon Dioxide (CO2)
- No Water

Wind Power Sizes and Applications

- **Small (≤10 kW) (kW- a unit of power equal to 1000 watts)**
- Homes (In 2005, the average monthly residential electricity consumption was 938 kilowatt hours (kWh), according to the Energy Information Administration.)
- Farms

Wind Power Sizes and Applications

- **Intermediate (10-250 kW)**
- Remote Applications (e.g., water pumping, telecom sites)
- Village Power Hybrid Systems
- Small Distributed Power

Wind Power Sizes and Applications

- **Large (250 kW – 2+ MW) (MW - a megawatt (MW) is one million watts)**
- Central Station Wind Farms
- Community Distributed Power


Small Wind Power for
Home, Farm, Business, & Schools
Farm
Industry
Business
Residential
Schools

Steps to Implement a Small Wind Project

- Assess your electricity consumption, cost, and utility tariff
- Assess wind resource & micro-siting
- Select turbine size (model) and tower height
- Assess incentives & economics
- Evaluate zoning requirements (including neighbor notification)
- Consider utility interconnection agreement potential
- Assess ability to secure building permits
- Assess availability of wind turbines and towers
- Determine installation costs
- Commissioning

*Source NREL

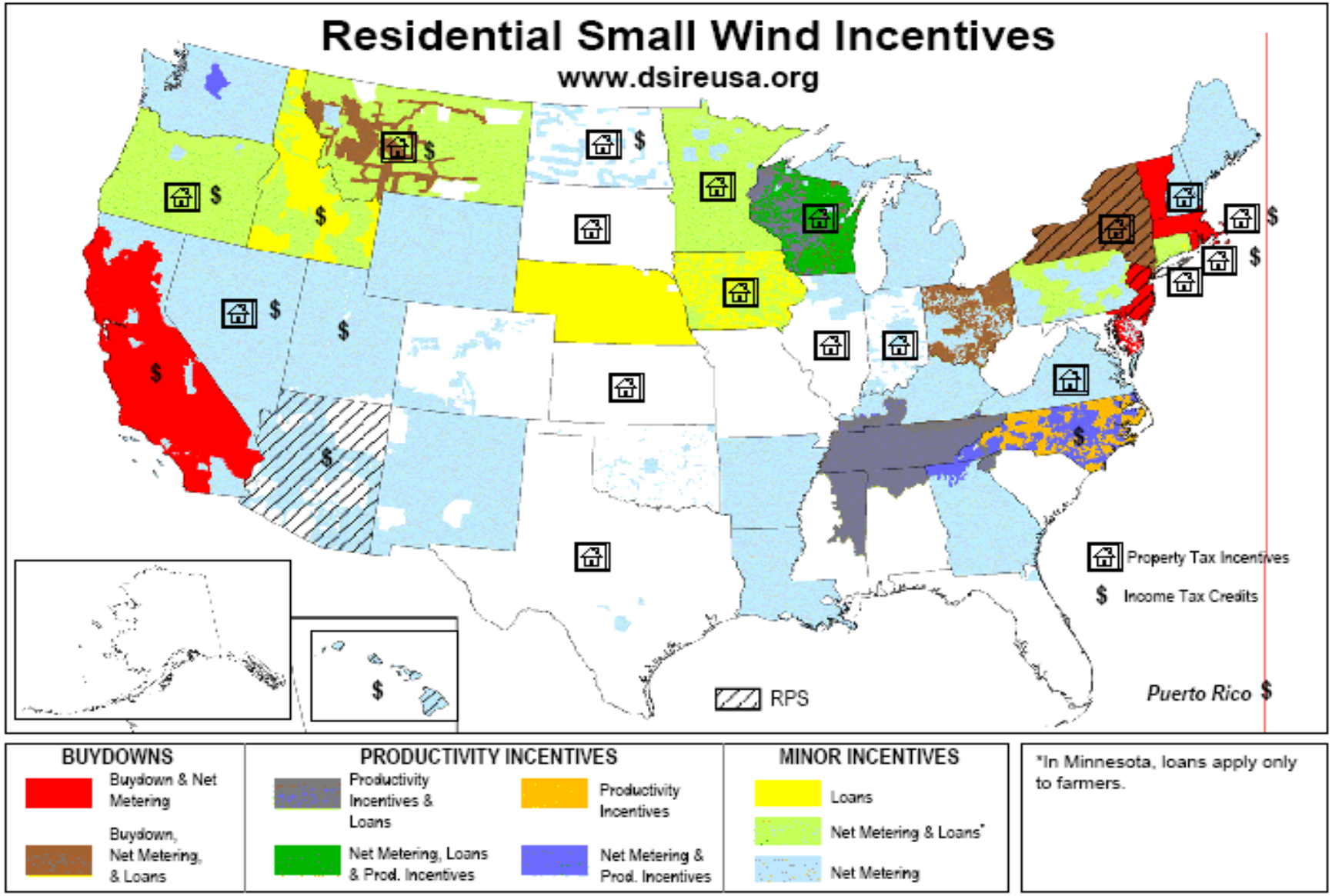
USDA Farm Bill Section 9006 Grants and/or Loan Guarantees

- Applies to Renewable Energy & Energy Efficiency:
  - Wind
  - Solar
  - Biomass
  - Geothermal
  - Hydrogen
  - Energy Efficiency
- **www.rurdev.usda.gov/rbs/farmbill**

USDA Farm Bill Section 9006
www.rurdev.usda.gov/rbs/farmbill

- For rural farms, ranches, small businesses (not for residential systems)
- Grants (up to 25% of project cost) and/or Loan Guarantees (up to 50% of project cost)
- Work with rural energy coordinators at your USDA State Rural Development Office
- Simplified application instituted in 2006 for projects < $200,000

*Source NREL



Federal Incentives: Mainstay Energy – green tag purchase (CA excluded); USDA Federal Farm Bill Title 9006 – grant for rural areas

May 30, 2006

*Source NREL

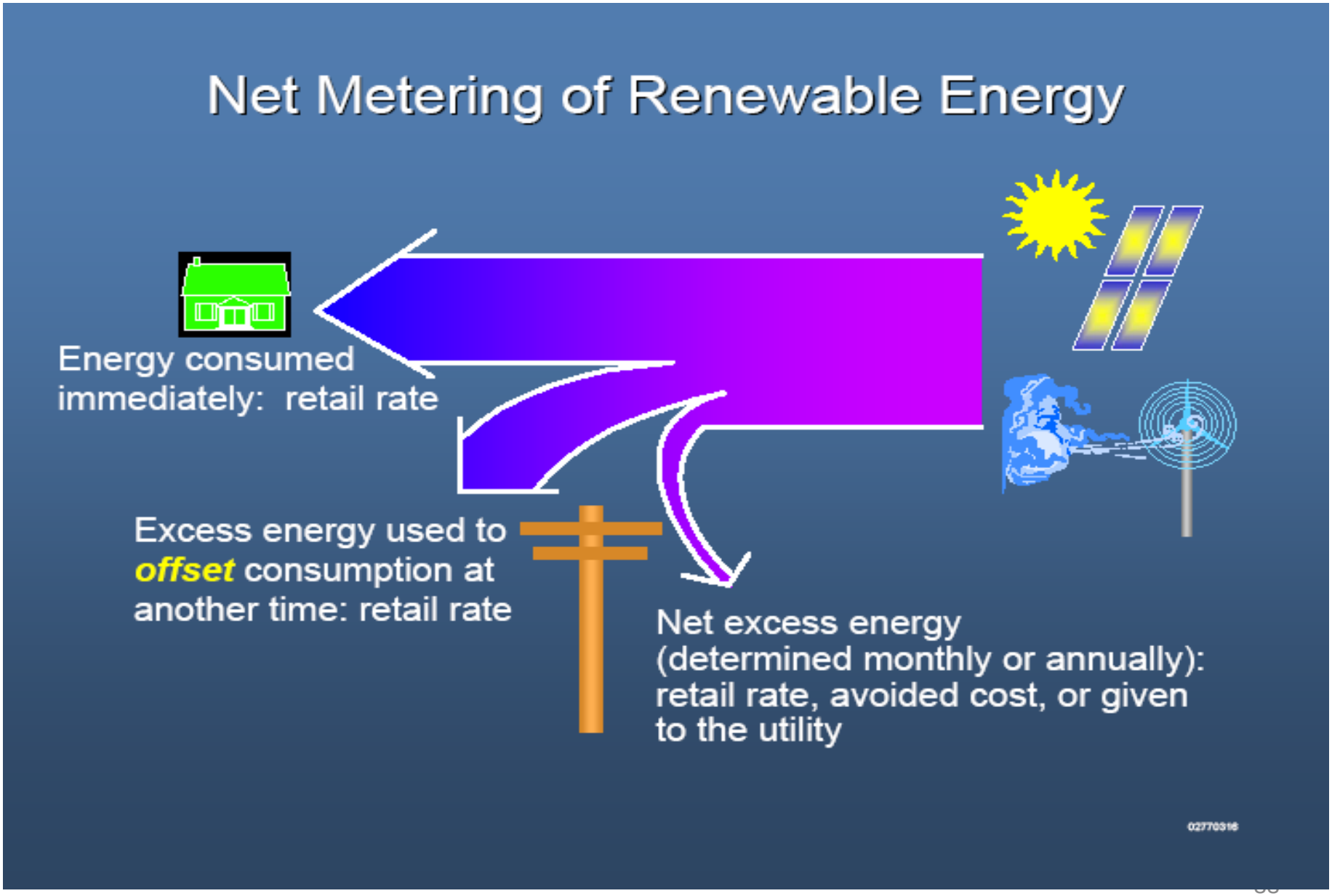
Net Metering of Renewable Energy

- Excess wind power turns the electric meter backward
- Bill is based on the "net" consumption/generation (monthly or annually)

- Net metering of wind energy is available to:
  - All residential (including rural) customers in 25 states
  - Some residential customers (mostly urban) in 15 other states

Apr02

*Source NREL


Net Metering of Renewable Energy
Energy consumed immediately: retail rate
Excess energy used to offset consumption at another time: retail rate
Net excess energy (determined monthly or annually): retail rate, avoided cost, or given to the utility
02770316

Colorado's Net Metering Program

- Established in 2004 and subsequently amended, is widely considered to be one of the best in the United States. Colorado allows net metering for systems sized up to 120% of the customers average annual consumption for all customers of investor-owned utilities. For customers of municipal utilities and electric co-ops, the limits are 10 kilowatts (kW) for residential systems and 25 kW for non-residential systems. There is no stated limit on the aggregate net metering capacity in Colorado. Any net excess electricity generated by a customer during a billing period is carried forward to the customer's next bill as a full kWh credit (i.e., at the utility's retail rate). At the end of a 12-month period, the utility purchases any remaining excess electricity from the customer at a rate lower than the retail rate. Alternately, customers can choose to roll-over the net excess generation credits indefinitely. Customers own the RECs associated with the electricity they generate.

Colorado RPS Credit Multipliers

- **Credit Multipliers**
  The Colorado RPS includes credit multipliers for four types of projects. These multipliers cannot be combined. One project can only receive one multiplier.
- Each kilowatt-hour (kWh) of eligible electricity generated in-state, other than retail DG, can receive 125% credit for RPS-compliance purposes.
- Electricity generated at a “community-based project” -- a project not greater than 30 megawatts (MW) in capacity that is located in Colorado and owned by individual residents of a community or by an organization or cooperative that is controlled by individual residents, or by a local government entity or tribal council -- can receive 150% credit for RPS-compliance purposes.
- Solar electricity located in the territory of a cooperative or municipal utility and generated by a facility that begins operation before July 1, 2015, can receive 300% credit for RPS-compliance purposes. (Solar electricity generated by a facility that begins operation on or after July 1, 2015, receives 100% credit.)
- Projects up to 30 MW that are interconnected to electrical transmission or distribution lines owned by a cooperative or municipal utility, which are installed prior to December 31, 2014 can receive 200% credit for RPS-compliance purposes. With the exception of investor-owned utilities using this multiplier, it is only available for the first 100 MW of projects statewide.

  Tradable renewable energy credits (RECs) may be used to satisfy the standard.

Renewable Energy Credits (RECs)

- What is a renewable energy credit (REC)?
- A renewable energy credit (sometimes referred to as a renewable energy certificate or "greentag") is an environmental commodity that represents the added value, environmental benefits and cost of renewable energy above conventional methods of producing electricity, namely burning coal and natural gas. RECs help wind farms and other renewable energy facilities grow by making them more financially viable, thereby incentivizing development.

Renewable Energy Credits (RECs)

- How does the REC system work?
- Renewable energy facilities generate renewable energy credits (RECs) when they produce electricity. Purchasing these credits is the widely accepted way to reduce the environmental footprint of your electricity consumption and help fund renewable energy development. Purchasing RECs at the same quantity as your electricity consumption guarantees that the energy you use is added to the power grid from a renewable energy facility and supports the further development of these facilities. May be purchased on market or from your utility.

Project Elements

- Understanding of wind resource
- Proximity to/availability of transmission lines
- Siting and project feasibility
- Site control
- Debt and equity financing
- Long-term power purchase arrangements
- Turbine supply
- EPC (Engineering, Procurement and Construction) and BOP (Balance of Plant) contracts
- Operations and maintenance arrangements

*Source NREL

Dale Osborn's Famous Diagram "Wind Project Development Process"

This is not always a straight forward process and the steps are not always in this order.
Sometimes the steps are repeated in an iterative fashion to optimize the economics of the project

- Site Selection
- Land Agreements
- Wind Assessment
- Environmental Review
- Economic Modeling
- Interconnection Studies
- Permitting
- Sales Agreements
- Financing
- Turbine Procurement
- Construction Contracting
- Operations & Maintenance

Wind Assessment

- Historically, meteorological towers (“met towers”) have been used with 1 year of data being required, depending on the project size and financing requirements.
- Average steady wind of 10-15 miles acceptable.

Wind Assessment Equipment

- Instruments
- –Anemometer
  - Type?
  - Calibrate?
  - Heated?
  - Cost
- –Wind vane
- –Logger
- –Data transmission

- Mounting

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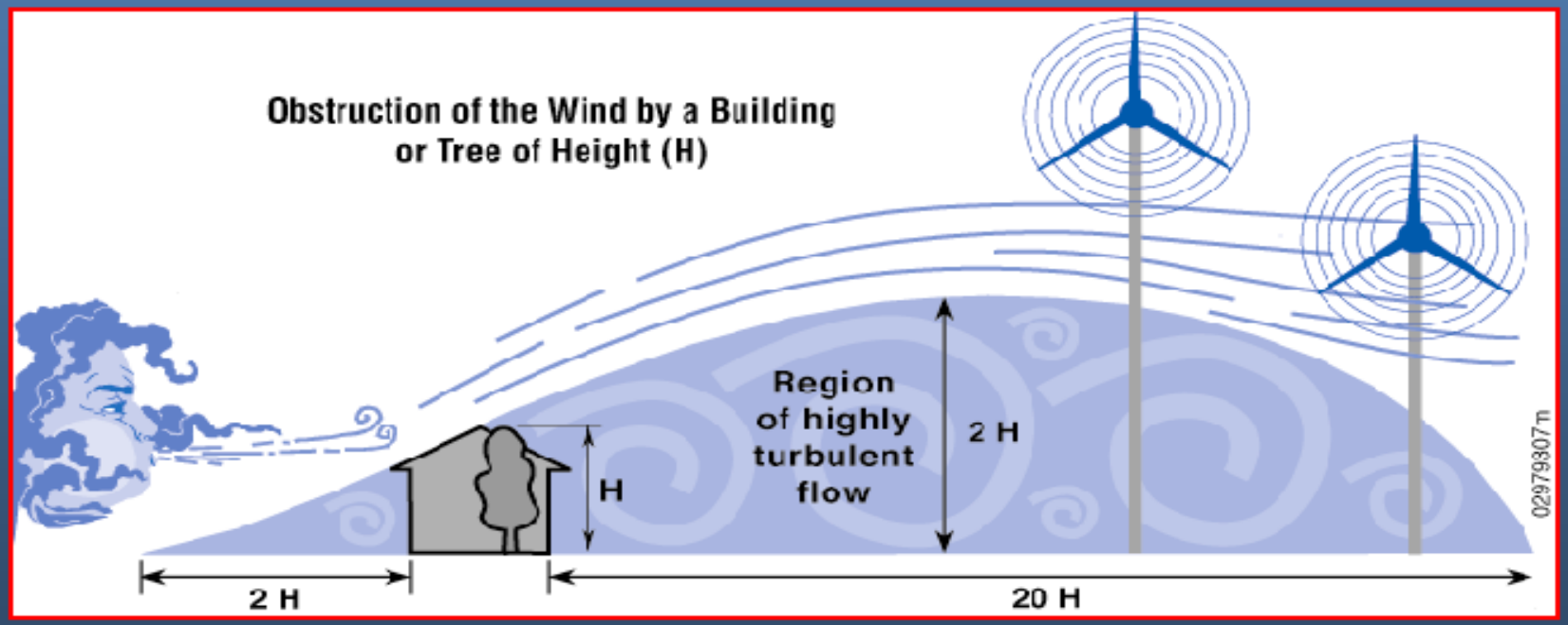
*Source NREL

Importance of "Micro-Siting"



Wind Resource Classes

- Vary by Height – At 50 m (164’)
- Prefer Class 4 or above for large scale projects
- Class 3 – 15.7 miles
- Class 4 – 16.8 miles
- Class 5 – 17.9 miles
- Class 6 – 19.7 miles
- Class 7 - >19.7 miles

Preliminary Site Control Considerations

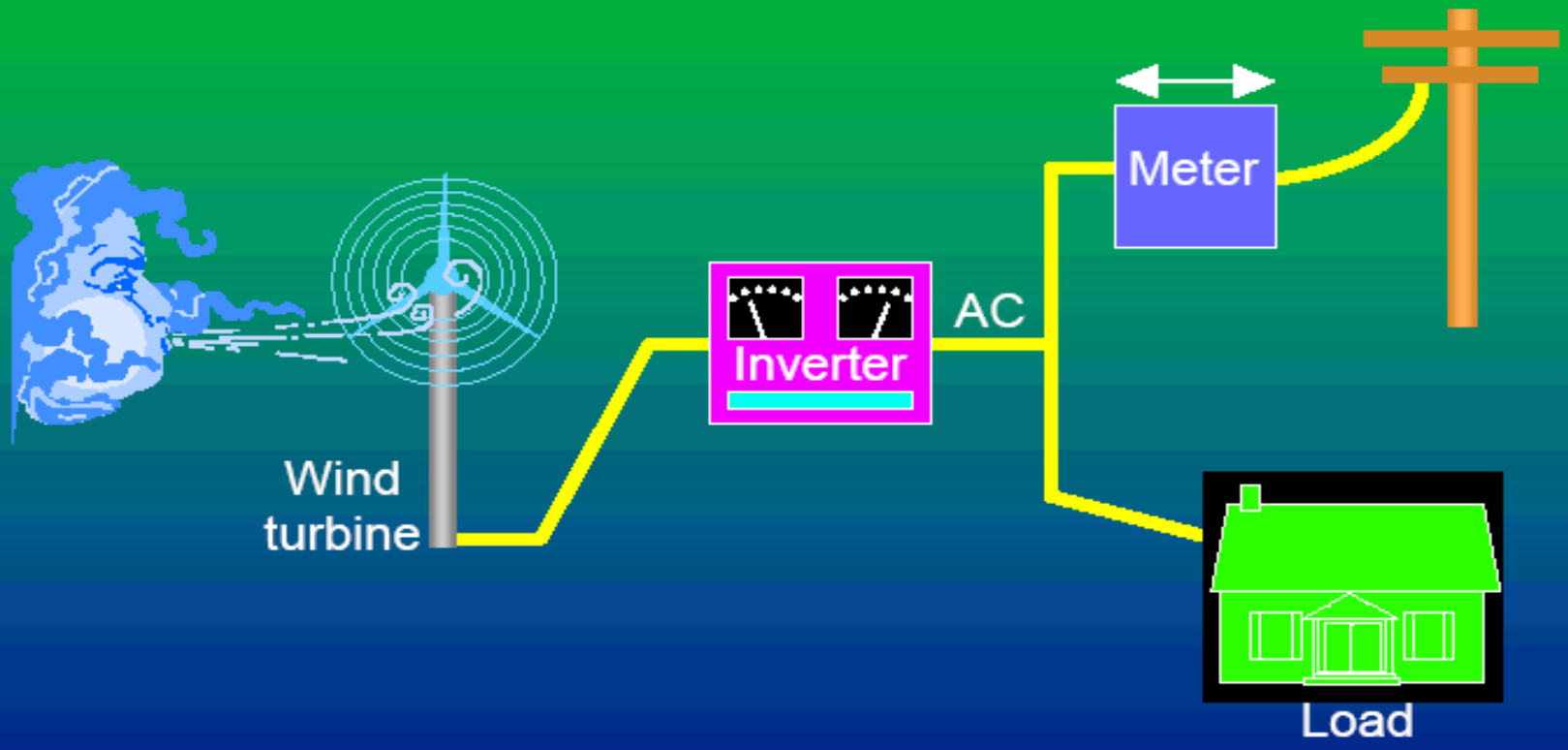
- **Purchase vs. lease**
- already a capital-intensive project
- land can be used for other purposes
- landowners reluctant to sell
- **Lease vs. easement**
- statutory requirements (e.g., Minnesota has wind easement or wind lease statute)
- legal burdens (e.g., property taxes, reporting requirements, jurisdiction)
- bankruptcy considerations (easement survives bankruptcy)

Site Selection

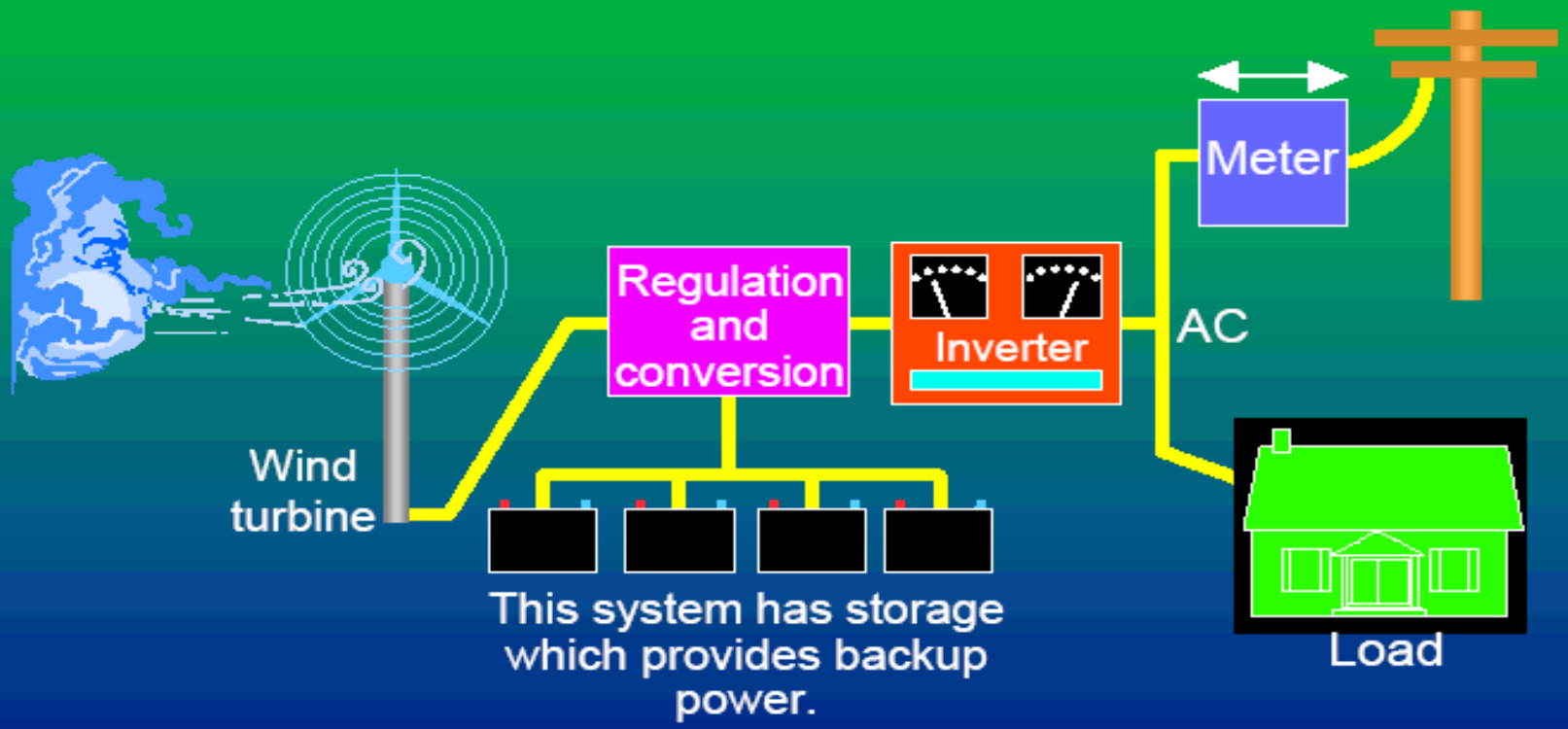
- Depends upon who the owner is and who the wind power end-user is
- Schools or businesses usually want turbine right at facilities
- Municipal and cooperative utilities want the turbine(s) to be near or in their service territory
- Larger projects are sited in windy areas relatively close to available transmission lines
- FAA height restrictions often affect projects near towns and cities

*Source NREL

On-Grid Wind System without Storage



On-Grid Wind System with Storage



Land Ownership Variables

- Land may already be owned by turbine owners – schools, businesses
- Land may be owned by project beneficiaries – municipal and cooperative utilities
- Land owned by unrelated third parties
- Developers do not have power of eminent domain
- **<u>Landman with deal-making experience is critical!!!</u>**

Lease Issues

- **Federal law and regulation govern leases on Indian trust lands (e.g., 25 USC §415; see also 25 CFR Pt. 162, and 25 USC §81)**
- **Long diligence term required**
- **Use of the land**
  - avian studies
  - environmental studies
  - archaeological/cultural resource studies
  - met towers

Lease Term

- **Term**
- Need long primary term (including construction period) with right of renewal. Limit under 25 U.S.C. §415 is 25 years with right of renewal, except as to certain tribes which may be for a longer term (including Southern Ute Indian Tribe).
- 25 U.S.C. §81 requires that certain contracts with Indian tribes be approved by the Secretary of the Interior or the Secretary's designee.

Lease Compensation

- **Compensation payments can vary**
- *option* - per acre, lump sum/per year
- *reserve fee* - per acre, lump sum/per year
- *operations period reserve fee* - per acre, lump sum/per year (commercial operation has started but generating unit not installed)
- *bonus* - per acre
- *installation* - per MW
- *royalties* – % of "gross revenue"
- definition of gross revenue
- minimum payments
- phantom turbines

Lease Compensation (cont'd)

- *production payment* - amt/MWh x MWh produced
- *alternative rent* - per acre per year
- *substation/O&M building* - lump sum or annual improvements fee
- *transmission/access road* - per rod
- *hunting* - lost revenue
- *crops* - per standard crop yield x market price
- *CRP compensation forfeited* - Conservation Reserve Program (CRP) is a cost-share and rental payment program under the United States Department of Agriculture (USDA)

Developer's Use Rights under Lease

- Installation of met towers; conduct of investigations/studies
- Installation/operation of project improvements
- Use of wind crossing the property
- "Overhang" rights
- Use of water, gravel, caliche
- General site access
- Noise, visual, other physical effects

Developer Covenants under Lease

- **Decommissioning**
- Landowner will want specific covenants of removal/restoration
  - Usually a bond or fund required to be established
    - timing
    - amount
    - procedures
- **Land management/preservation**
  - road maintenance; livestock/improvement care; fences and gates
  - varying degrees of extent and complexity

Landowner's Retained Use Rights

- Farming, Ranching
  - a main selling point
- Residential use
- Hunting
- Mineral development

Other Key Subjects under Lease

- **Substation site acquisition**
  - lease(s) must anticipate transmission provider's requirements
- **Assignment and transfer**
- **Indemnity**
- **Rights on termination, default**
- **Dispute resolution**

Tribal Joint Venture – Traditional Model

- Sponsor (tribe and/or a tribal entity such as an enterprise, tribal corporation or Section 17 corporation)
- Developer (could be tribe or non-tribal entity – needs tax credits)
- Project company between tribal sponsor and developer formed to carry out:

  Development

  Construction

  Operation

Joint Venture Process

- Usually begins with a non-binding Letter of Intent coupled with a Confidentiality and Nondisclosure Agreement

Major Issues in Joint Venture Structure

- Preconstruction development budget
- Project schedule and milestones
- Delineation of development activities and responsibilities between tribal sponsor and developer
- Rights of compensation before and after financial closing
- Allocation of development costs
- Property rights and compensation
- Taxation
- Shareholder rights, especially minimum proposed minority shareholder protections (e.g., anti-dilution, rights to acquire interests in the project and project company, management issues)

Major Issues in Joint Venture Structure

- Dispute resolution, governing law, choice of forum
  - Waiver of defense and right of sovereign immunity
  - Exhaustion of remedies in tribal courts
  - Arbitration vs. litigation
- Indemnification, limitation of liability, remedies on default and termination, lender liens

Flip Structure Basics

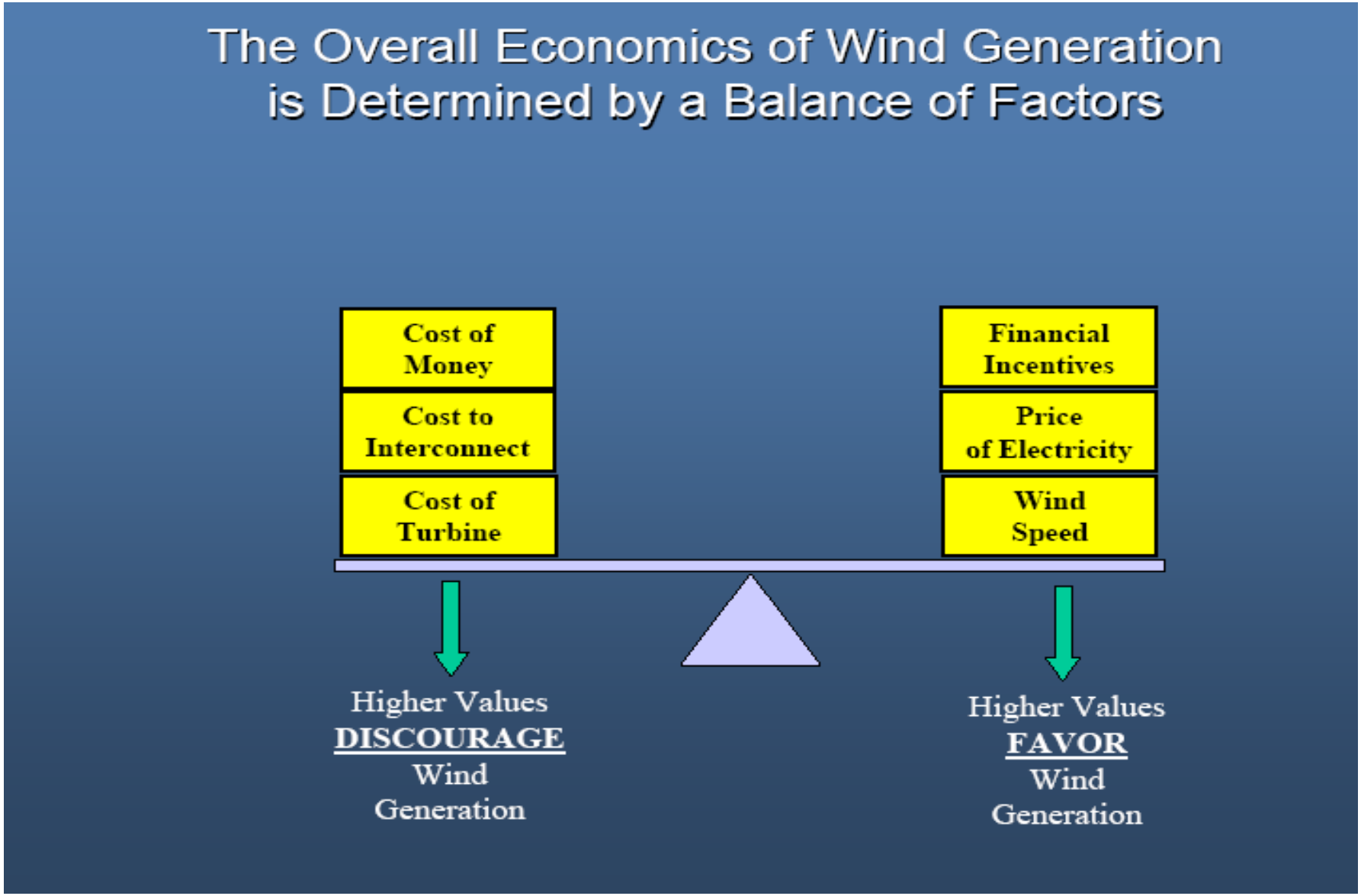
- “Flip structure” used since tribes don’t need tax benefits which is one of key incentives to renewable energy development. Results in complex arrangement.
- Flip structure agreement provides for percentage interests among investors, usually 90% or more to tax equity investor and remainder to tribal sponsor/developer. Percentages vary by deal.
- After 10 year period, or longer period for PTC investor to meet agreed-upon internal rate of return, percentage interests “flip” such that tribal sponsor/developer holds 90+% and PTC investor holds 10%
- Usually combined with a purchase option for the PTC investor’s interest after the flip

Economic Modeling

- Extremely important
- Preliminary evaluations are often done for site selection purposes
- More detailed evaluations are done for design and layout optimization
- Very comprehensive due diligence required to secure outside financing

*SOURCE NREL

*Source NREL


The Overall Economics of Wind Generation is Determined by a Balance of Factors
Cost of Money
Cost to Interconnect
Cost of Turbine
Financial Incentives
Price of Electricity
Wind Speed
Higher Values DISCOURAGE Wind Generation
Higher Values FAVOR Wind Generation

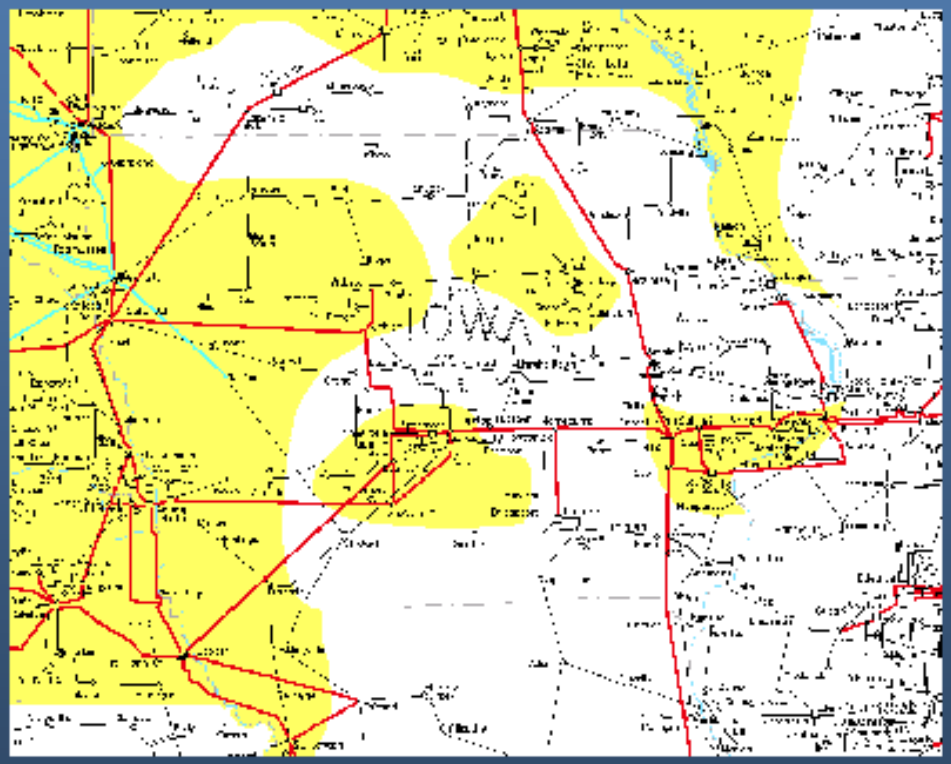
Economics of a Wind Project

- **"Simple Payback" is an easy way to measure the economic merit of a wind turbine project:**
- (Installed cost, $) ÷ (kWh/y X Price of Electricity, $/kWh) (years)
- "Cost of Energy" is another measure of economic value: Annual Cost of Ownership ÷ Annual Energy Production (cents/kWh)

*Source NREL

*Source NREL

Interconnection Studies

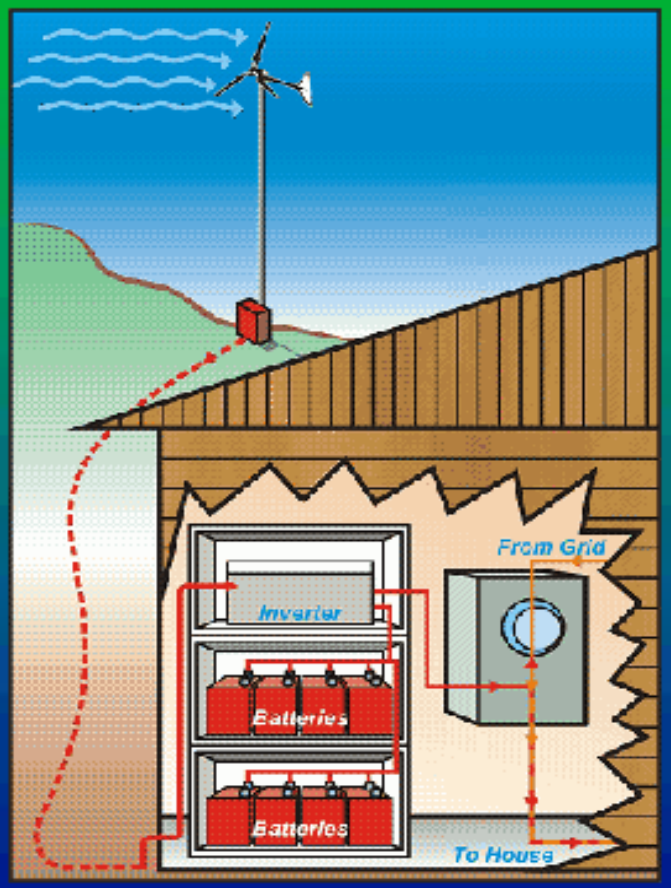


- Small projects are much easier. If under 2 MW, then it may be a simple check of power quality impacts if connected to the distribution system costing $500 to $2,500
- Projects less than 20 MW may cost $2,500 to $50,000 in studies
- Larger projects might cost $50,000 to $500,000
- An interconnection agreement is required in all cases.

*SOURCE NREL

Connecting to the Utility

- PURPA requires utilities to connect small wind systems and purchase power
- Safety & Power Quality – comply with national standards
- Tariff
  - Net metering (single meter)
  - Dual meters
  - Demand charges
- Interconnection Agreement
- Liability insurance



Interconnecting the Project

- System Capacity
- Interconnection Points
- System Upgrades
- Public Utilities Commission Approval
- Cost Allocation

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Permitting

- May be very simple for small projects in rural areas that have few regulations
- Typically county or city approvals needed
- May include state environmental agencies
- Some states have formalized processes depending upon size of project
- FAA rules often impact siting

Permitting

- On tribal lands, tribal government permitting requirements apply.
- Environmental Impact Review
- Natural and Historic Resources Protection
- Electrical and other technical permits

Sales Agreements

- If turbine is used to supply owner with power that it uses, then no sales agreement is needed unless there is excess power to be sold to the utility
  - Schools & businesses
  - Municipal, cooperative utilities
- Larger projects usually need a Power Purchase Agreement ("PPA") because power is sold
- Sales of Renewable Energy Credits

Financing

- Some projects are financed internally:
  - usually very small projects when the owners use available cash
- For large projects owned by large corporations or utilities:
  - Usually commercial loans or bonds are needed (CREBS - Clean Renewable Energy Bonds)
  - If income tax benefits can’t be used by owners, then an outside equity partner is usually needed with a partnership flip financial structure

*Source NREL

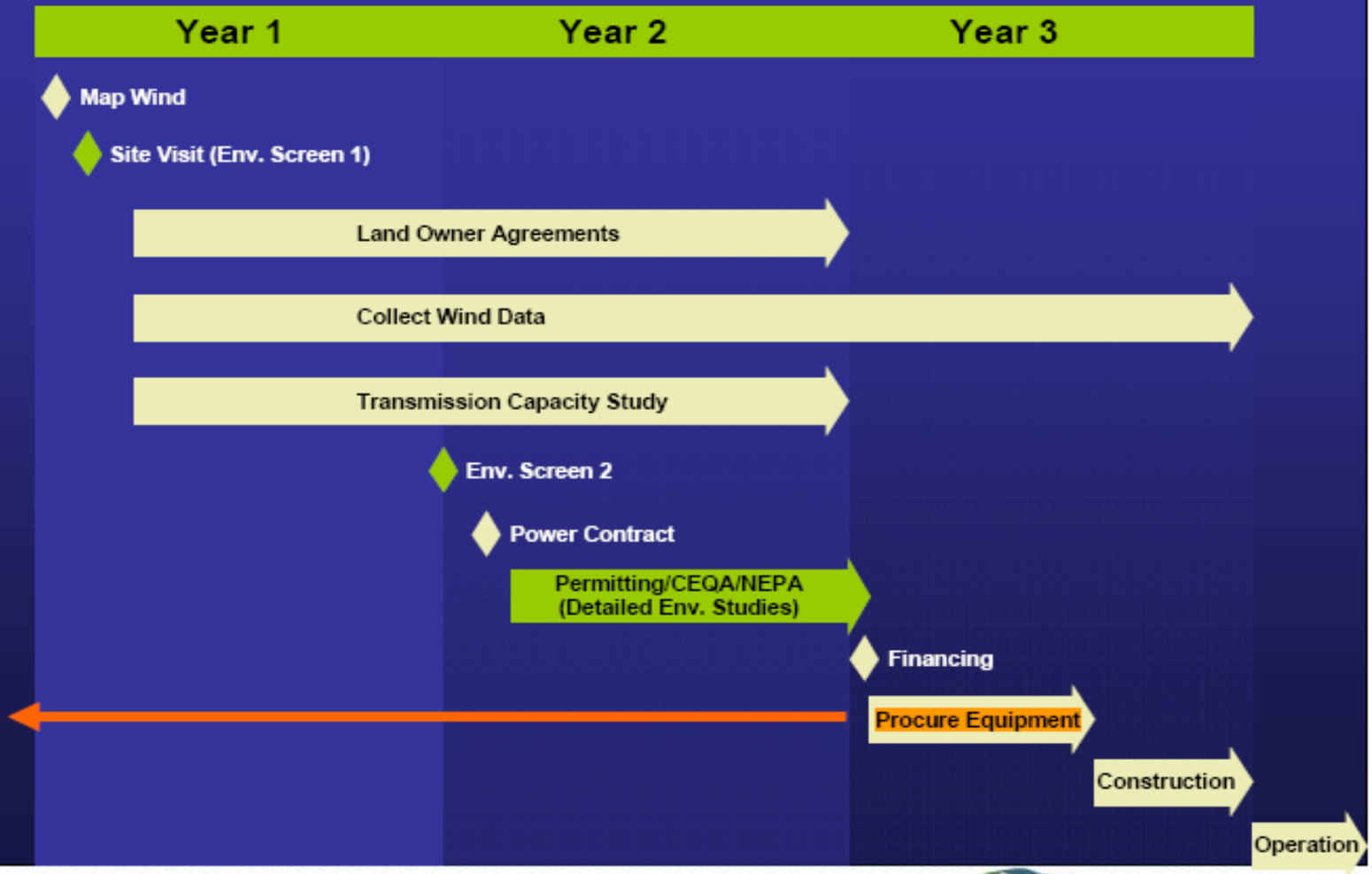
Financing – Wind Energy Investment Attraction

- Stable revenue from long-term contracts
- Proven technology with strong warranties
- Low operating costs/risks
- Predictable wind resource
- Tax incentives
- Attractive and predictable risk/return

Wind Energy Investment Challenges

- Heavy tax incentives component
- PTC ownership requirements
- PTC uncertainty
- Tax market very specialized
- Transmission constraints
- Curtailment or operating shutdowns

Typical Wind Project Development Process



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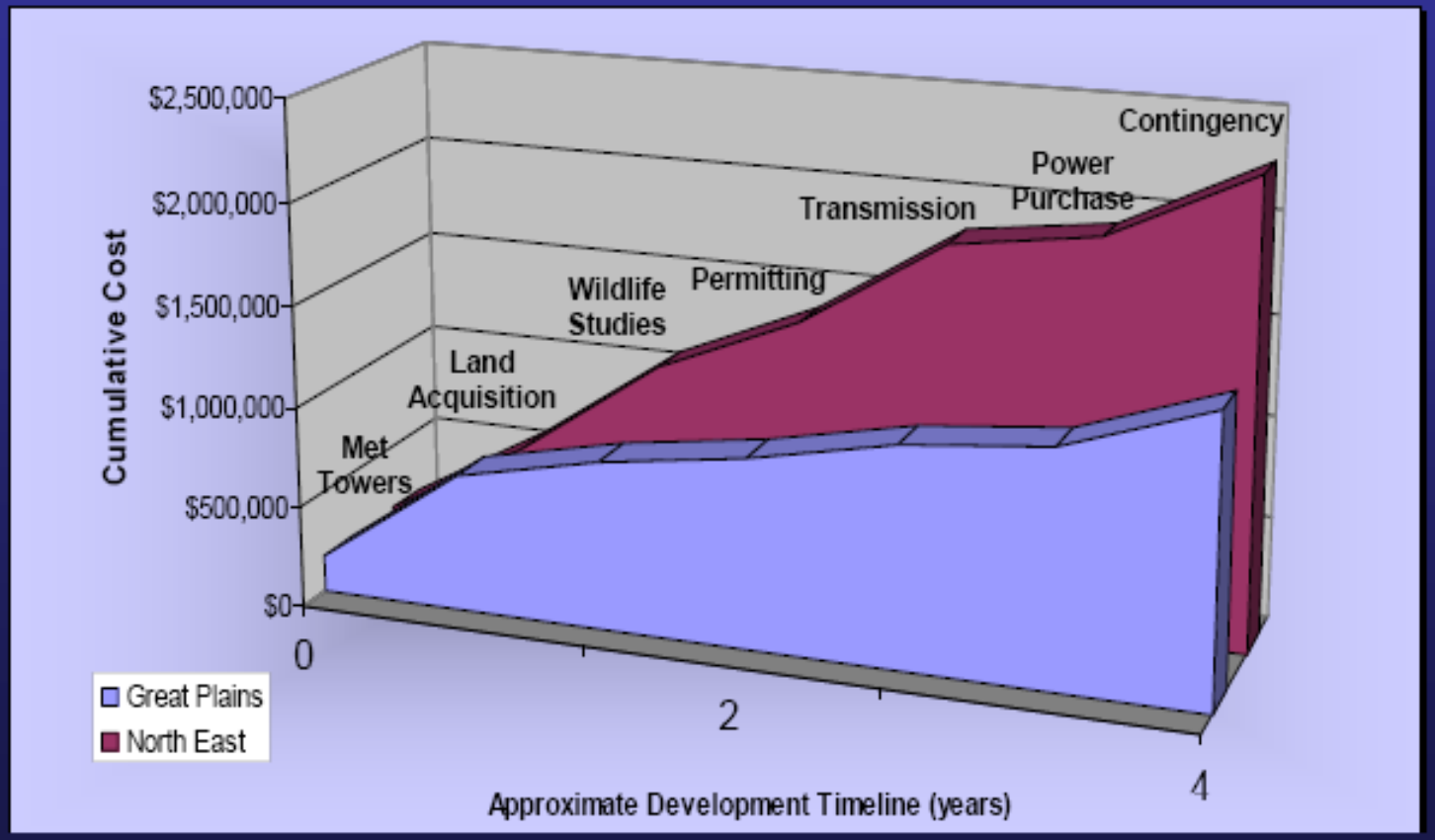
Development Dollars Expended Over Time



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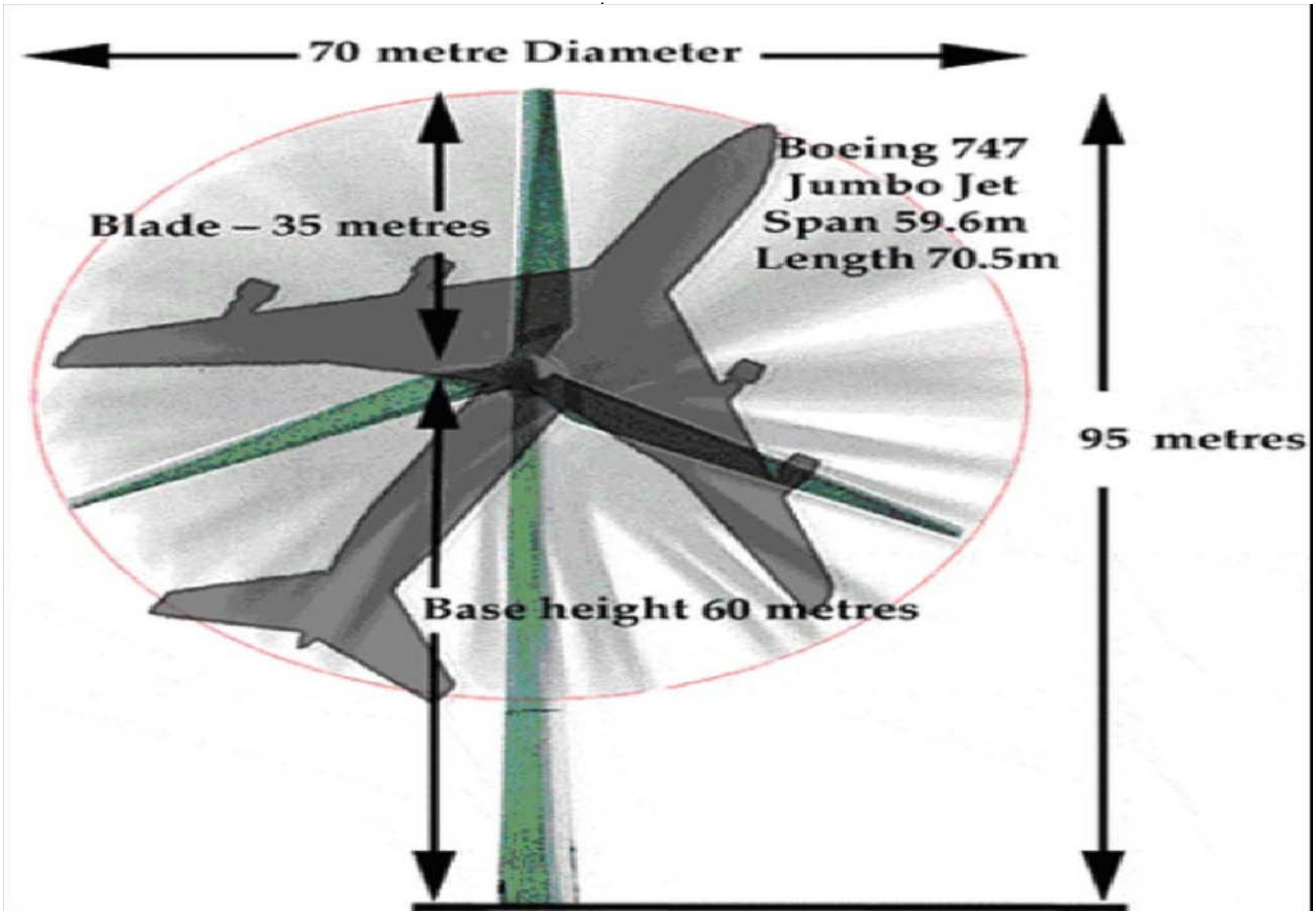
Turbine Procurement

- Difficult today
- Manufacturers can be picky…they can select their customers
- May need to use small niche manufacturers
- Can get turbines through larger developers who buy them in large lots. They may want to be partners in the project.
- Various types and numbers of turbines become available due to changes in developer's plans

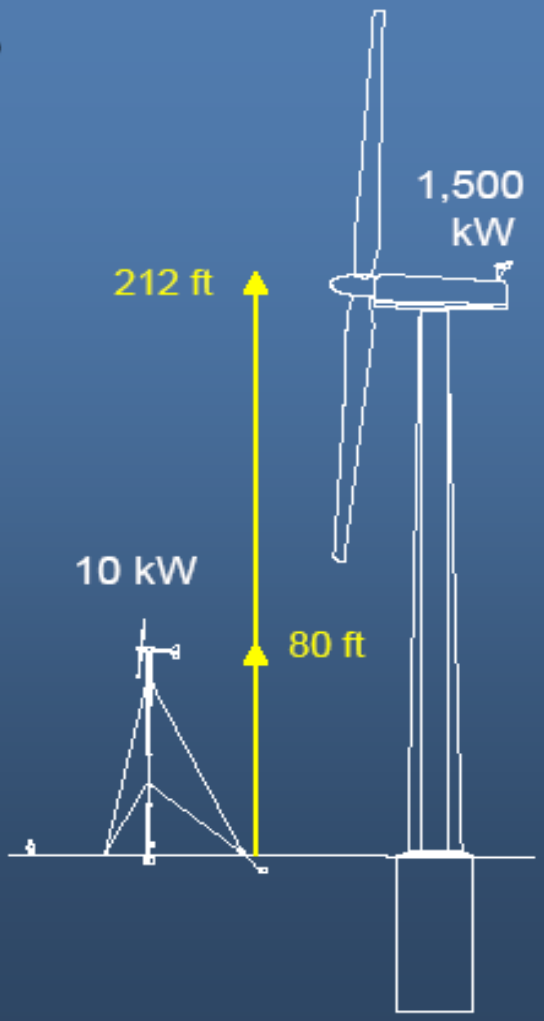
*Source NREL


70 metre Diameter
Boeing 747
Jumbo Jet
Span 59.6m
Length 70.5m
Blade – 35 metres
95 metres
Base height 60 metres

*Source NREL

Small Wind Turbines Are Different

- Utility-Scale Wind Power
  1,000-2,500 kW wind turbines
  - Installed on wind farms, 10–300 MW
  - Interconnected to transmission
  - Professional maintenance crews
  - Class 4-6 wind resource
- Small Wind Power
  up to 100 kW wind turbines
  - Installed at individual homes, farms, businesses, schools, etc.
  - Interconnected to distribution, on the "customer side" of the meter
  - High reliability, low maintenance
  - Class 2-3 wind resource



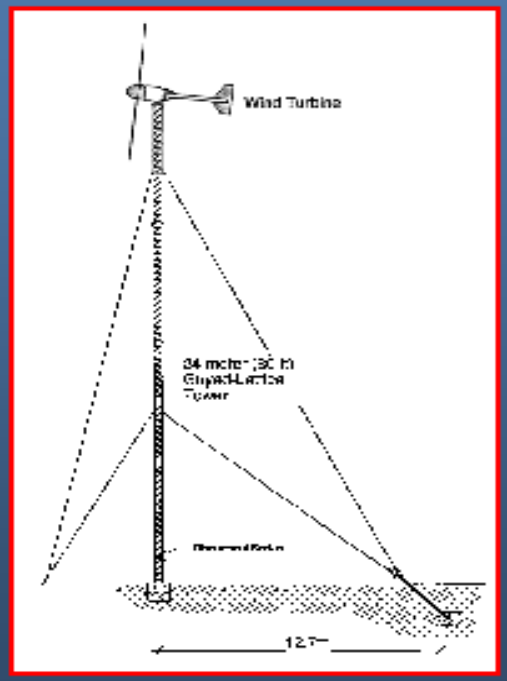
Small Turbine Technology Trends

- Advanced blade manufacturing methods
- Rare earth permanent magnets
- Grid-connected inverters
- Induction generators
- Design for low wind speeds
- Alternatives to furling for rotor speed control
- Reduced rotor speeds - reduced noise
- Design standards

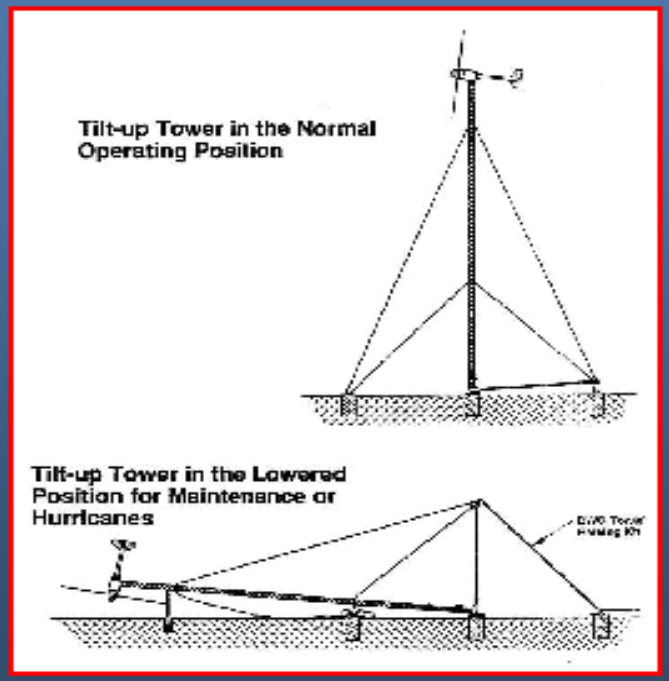
*Source NREL

*Source NREL

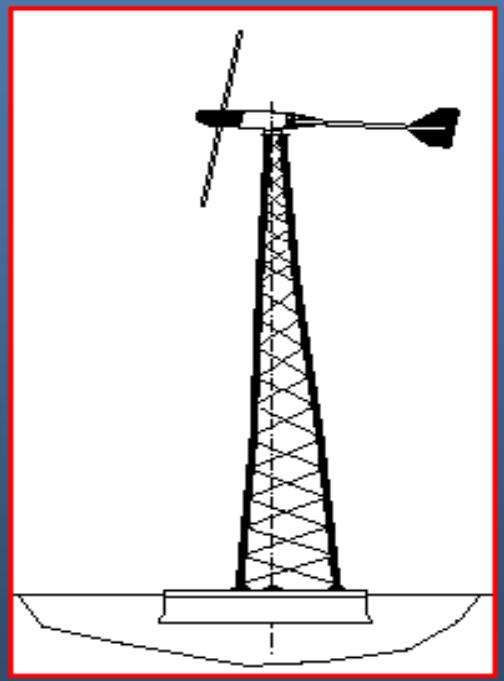
Small Wind Turbine Towers



Guyed Tower



Tilt-Up Tower



Self-Supporting Tower

Construction Contracting

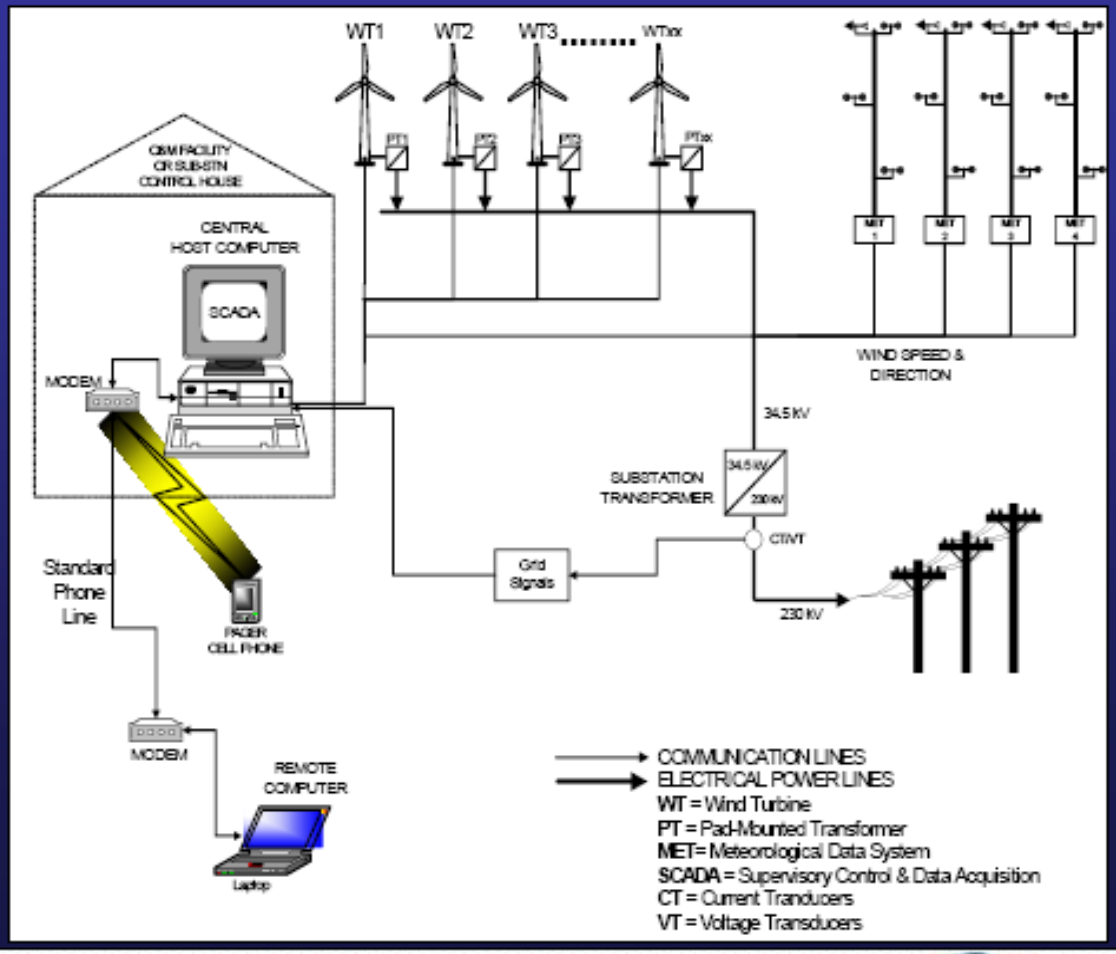
- Small projects may use local contractors or project managers that hire various local area subcontractors – may be a turnkey contract.
- Large projects may hire large companies to provide a variety of engineering, procurement, and construction services.

*Source NREL

Windfarm Components

- **Typical Windfarm 80-120 MW, 50-75 turbines**
- ~ 50 acres of unobstructed land per turbine
- **Electrical Collection System –** cables that electrically connect wind turbines to project substation
- **Substation** – steps up project generation to interconnection voltage
- **O&M Building/Yard –** houses central office, computer systems for facility operations, equipment storage, etc.
- **SCADA System** – "Supervisory Control and Data Acquisition" - computer system monitoring and control.
- **Access Roads** – link wind turbine strings to existing roads

Wind Plant Design



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Construction Sequence

- Roads
- Foundations
- Electrical Collector System
- Wind Turbine Generator
  - Tower
  - Setting the generator
  - Rotor assembly
- Interconnection
- Commercial Operation

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Road Construction

Grading

- Prepare road for construction

Drainage

- Install culverts, fords at drainage areas

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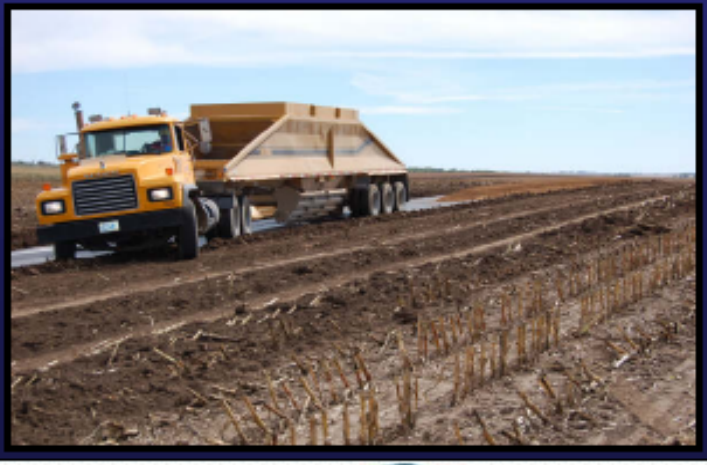
Road Construction (cont.)

Install Base Material:

- Place geo-fabric or Geo-Grid on top of compacted 16 to 20 foot wide road sub-grade.
- Place 6 to 8 inches of gravel over road surface.
- Finish road profile slightly above natural grade with a 2% crown in the center to promote drainage.
- Construct shoulders with a maximum of 2% side slope for crane travel (reclaimed after construction).



Turbine Foundations

Tower Pier Foundation with Spreadfooter Example

- Footing: 50-80 ft diameter, 4ft depth with taper.
- Pier: 16-20 ft diameter, 3ft height.
- Apron: Compacted area over footing diameter with 6 in rock surface.

Construction:

- Excavation depth to ~8ft and +40ft base elevation.
- Mud Mat – 2 to 4 inches lean concrete.
- Rebar cage and anchor bolts cage.
- Concrete (5000 psi) formed and poured in two lifts.
- Backfill with native soil

Tower Erection

- The 80-meter turbine tower is composed of four cylindrical steel sections.
- The four tower sections are typically unloaded adjacent to each wind turbine foundation to minimize handling of these heavy steel components.
- Each tower section weighs between 35 and 50 tons.

Tower Erection

- The lower tower section is set first. A flange on the bottom of this 15' diameter section allows it to be bolted to the top of the foundation pedestal.
- After the tower sections are set, the nacelle is raised and bolted to the top of the tower.
- A 2 megawatt class turbine nacelle weighs over 100 tons.

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Tower Erection

- The rotor assembly is erected last.
- The rotor consists of three blades and a hub that mounts on the front of the nacelle.
- Typically, the blades and hub are assembled on the ground and then raised as a single unit, called the rotor, and attached to the nacelle.

Collector Cable Construction

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Collector Substation

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Collector Substation

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O&M Building

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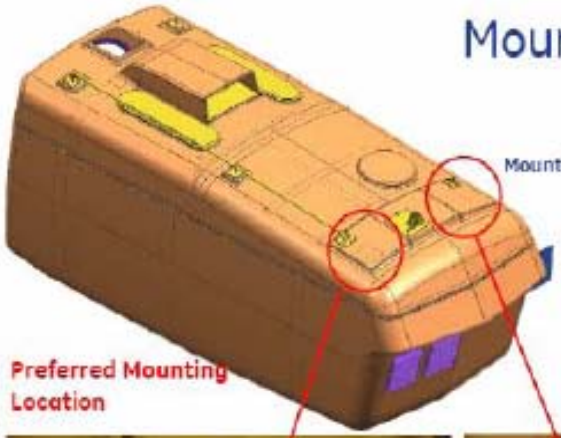
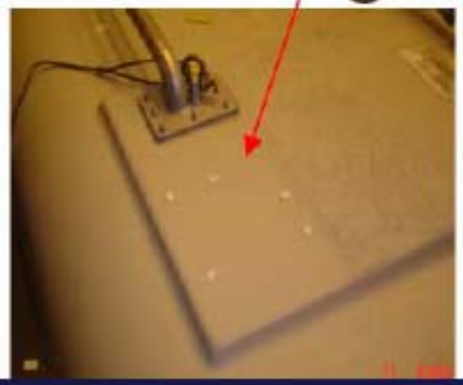
FAA Lights

Mounting the FAA Light





For illustrative purposes only

Bracket Assembly Schedule (Top->Down):

- *FAA Light*
- *Bolts, Nuts, Washers – Light to Bracket*
- *Bracket*
- *Sikaflex Bed*
- *Bolts, Washers – Bracket to Nacelle*

Installation Notes:

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Operations and Maintenance

- Small projects
  - May use manufacturer's personnel initially
  - May use local staff members after they are trained
- Larger projects will often rely on manufacturers during the warranty period, and then hire their own staffs after that

*Source NREL

Sources of Information

- National Energy Renewable Laboratory
  Tribal Energy Program (NREL TEP)
  http://apps1.eere.energy.gov/tribalenergy
- Business & Legal Issues in Tribal Energy Projects, Douglas C. MacCourt, Ater Wynne LLP, dcm@aterwynne.com
- American Wind Energy Association http://www.awea.org/

Sources of Information

- Catching the Wind: An Insider's Perspective on Legal Issues in Wind Energy Development, Wayne Walker, Conservation Consulting LLC
- The Future of Siting and Building Energy Infrastructure, Making Renewable Energy Work, Sharon Buccino, Natural Resources Defense Council

Sources of Information

- The Future of Siting and Building Energy Infrastructure, Renewable Project Development and Finance, R. Jeffrey Lyman, Goodwin Procter LLP
- Wind Law: The Essentials of Wind Leases, Robert P. Wright, Baker Botts LLP

Thank You For Coming!!

- Please let us know what other subjects you are interested in.