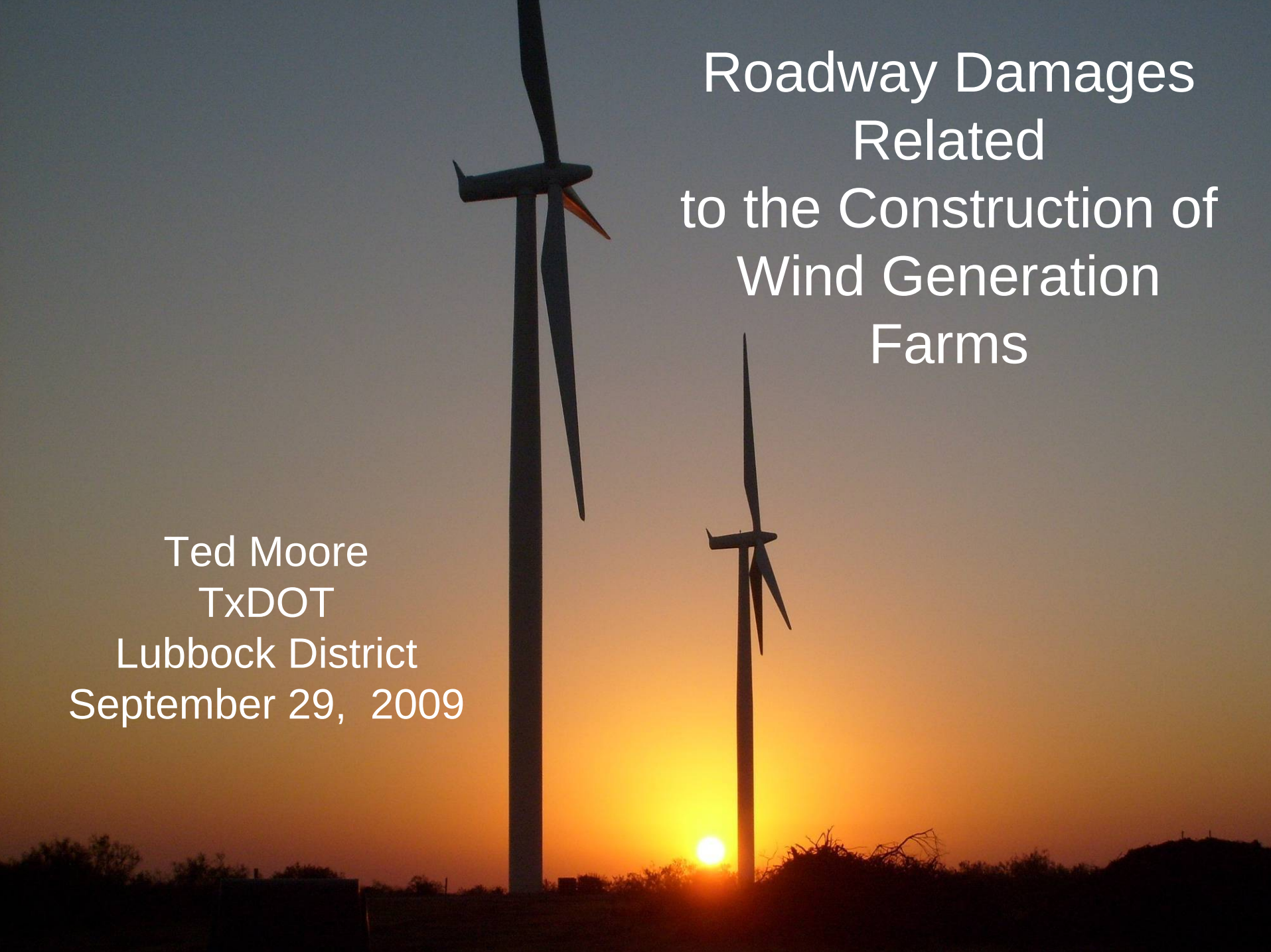
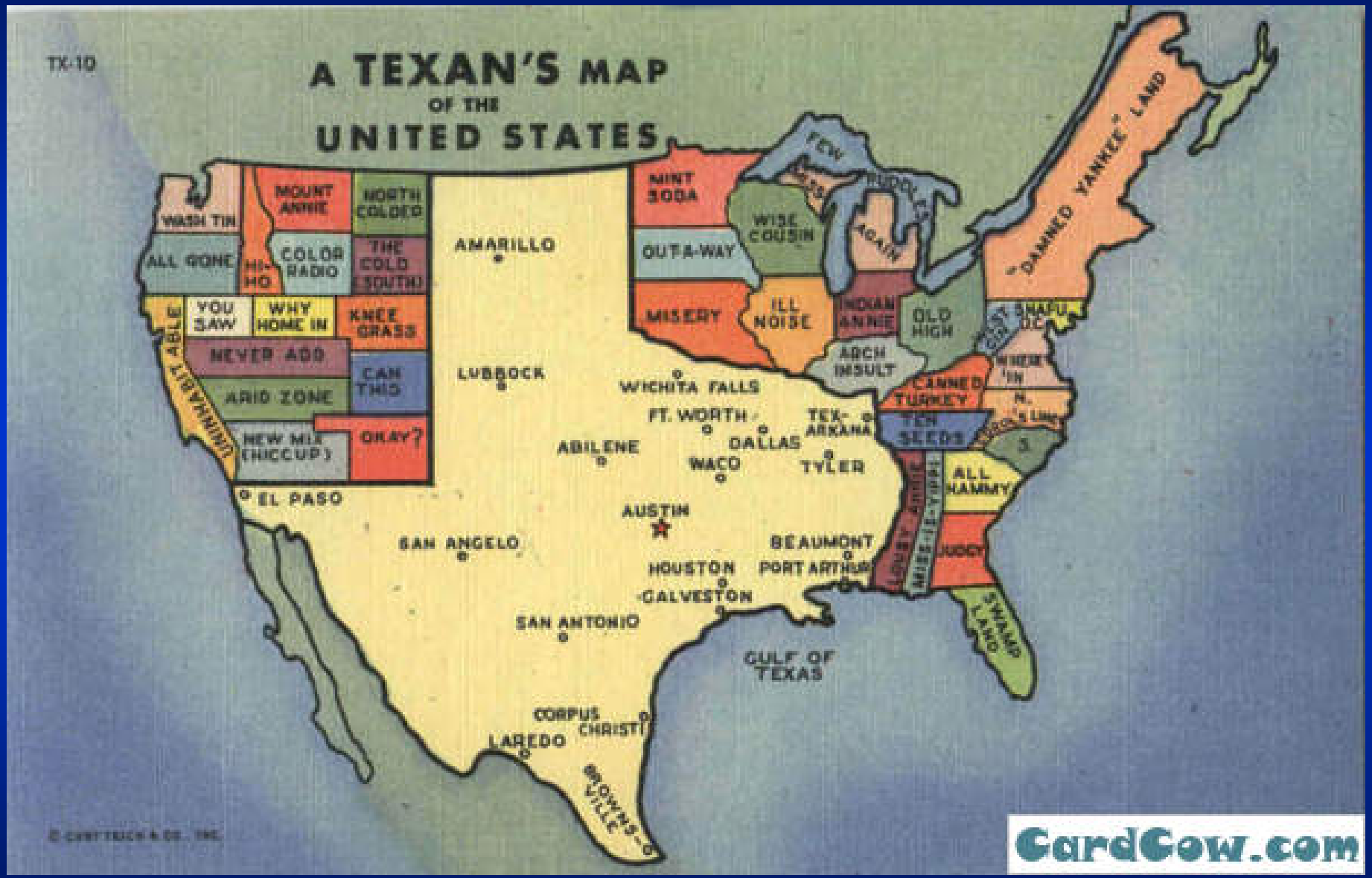


Roadway Damages Related to the Construction of Wind Generation Farms

Ted Moore
TxDOT
Lubbock District
September 29, 2009

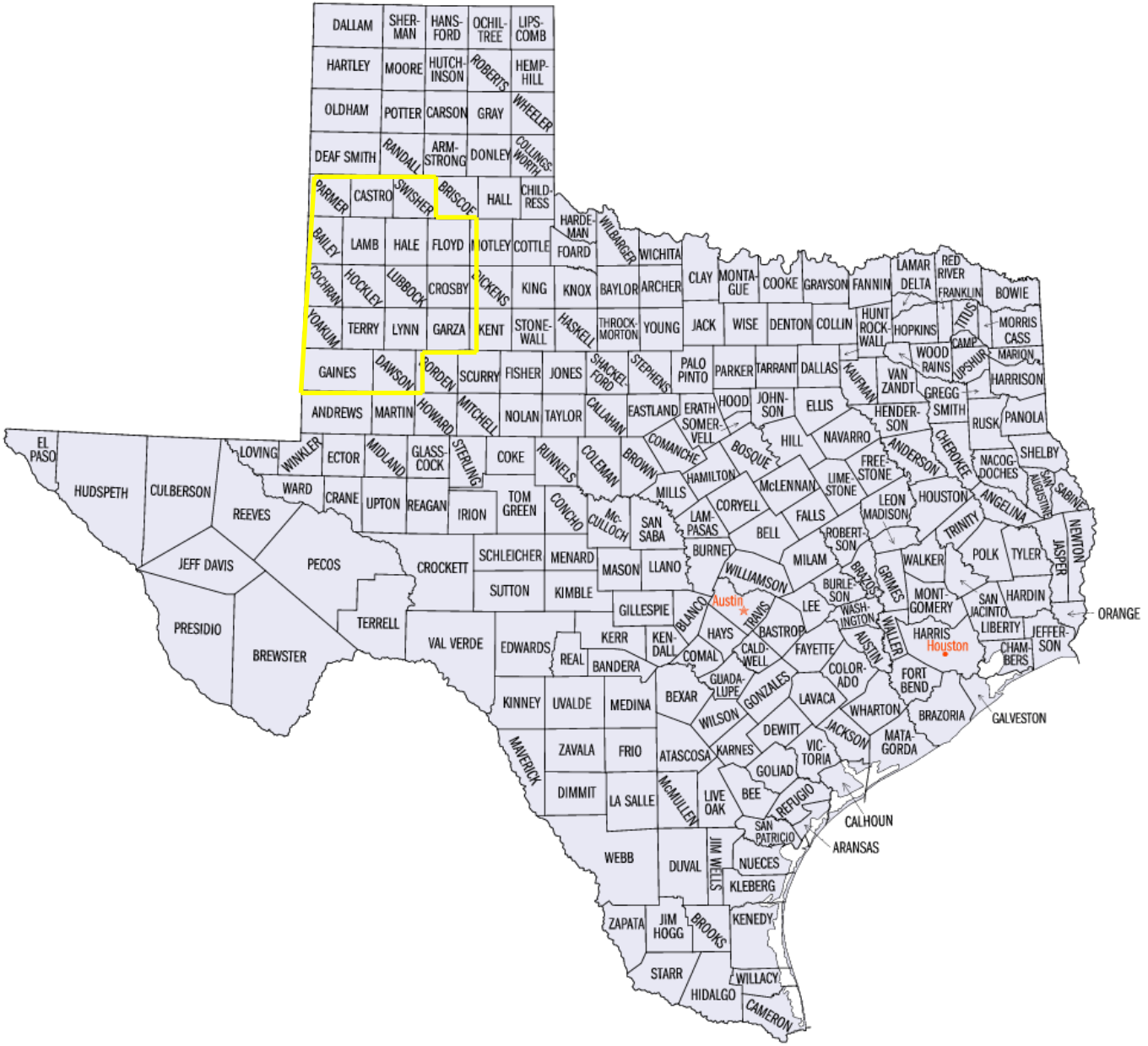
Agenda

- Background Information
- Wind Power Industry Construction
- Potential Roadway Damages
- Specific Impacts in the Lubbock District
- Conclusions/Recommendations


TX-10
A TEXAN'S MAP
OF THE
UNITED STATES
WASH TIN
MOUNT ANNIE
NORTH COLDED
ALL GONE
HI-HO
COLOR RADIO
THE COLD SOUTH
YOU SAW
WHY HOME IN
KNEE GRASS
NEVER ADO
CAN TWO
ARID ZONE
NEW MEX (HICCUP)
OKAY?
EL PASO
AMARILLO
LUBBOCK
MINT SODA
OUTA-WAY
WISE COUSIN
MISERY
ILL NOISE
INDIAN ANNIE
OLD HIGH
ARCH INSULT
"DAMNED YANKEE" LAND
CANNED TURKEY
TEN SEEDS
WICHITA FALLS
FT. WORTH
TEX-ARKANA
DALLAS
ABILENE
WACO
TYLER
ALL HAMMY
AUSTIN
SAN ANGELO
BEAUMONT
PORT ARTHUR
HOUSTON
GALVESTON
SAN ANTONIO
GULF OF TEXAS
SWAMP LAND
CORPUS CHRISTI
LAREDO
BROWNSVILLE
CardCow.com

US STATES

Produced by the Dept. of Geography
The University of Alabama


DALLAM
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OLDHAM
POTTER
CARSON
GRAY
WHEELER
DEAF SMITH
RANDALL
ARMSTRONG
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CASTRO
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GUADALUPE
GONZALES
LAVACA
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GALVESTON
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KARNES
VICTORIA
GOLIAD
DIMMIT
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McMULLEN
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SAN PATRICIO
CALHOUN
ARANSAS
WEBB
DUVAL
JIM WELLS
NUECES
KLEBERG
ZAPATA
JIM HOGG
BROOKS
KENEDY
STARR
WILLACY
HIDALGO
CAMERON


DALLAM
SHERMAN
HANSFORD
OCHILTREE
LIPSCOMB
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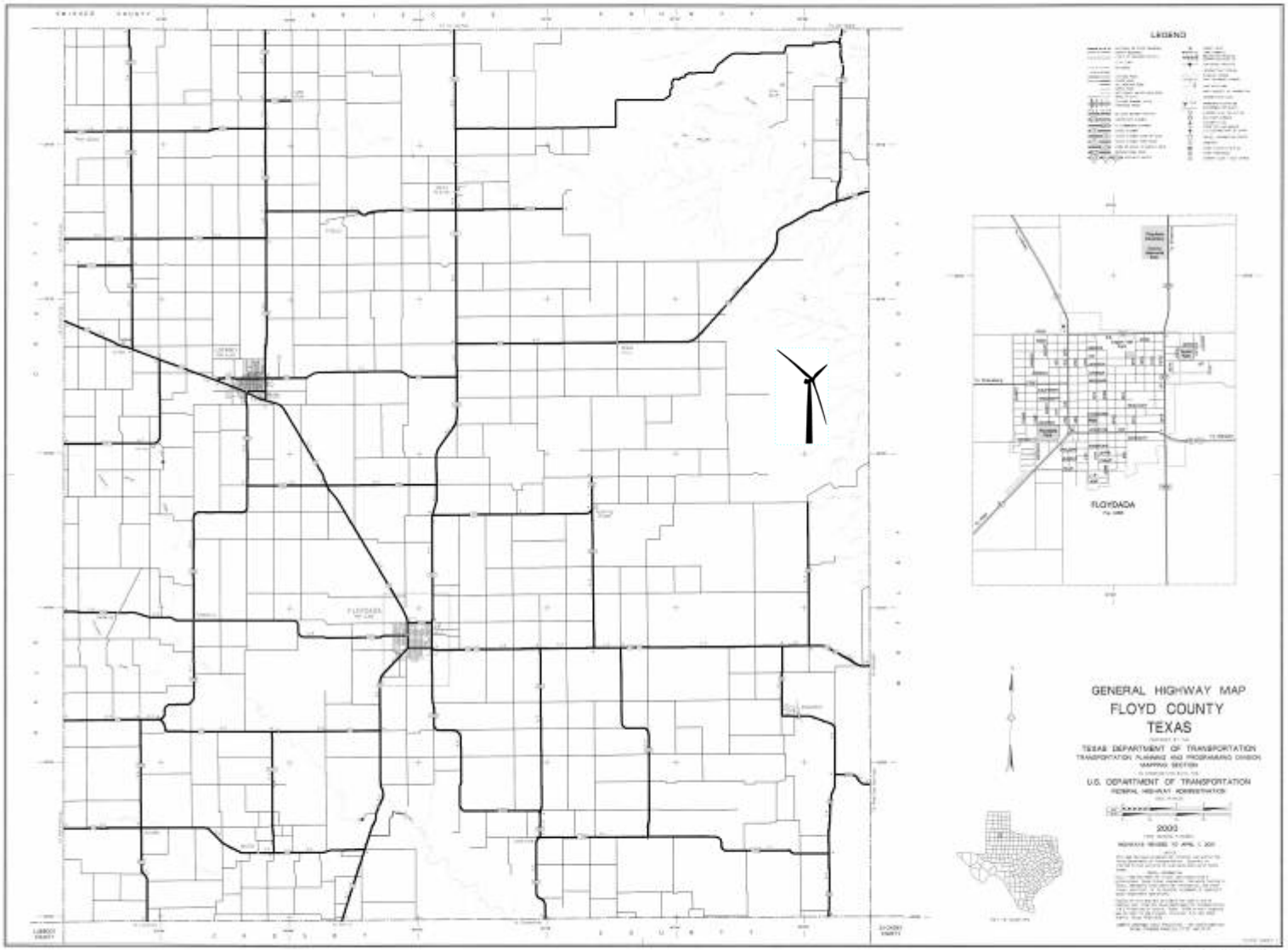
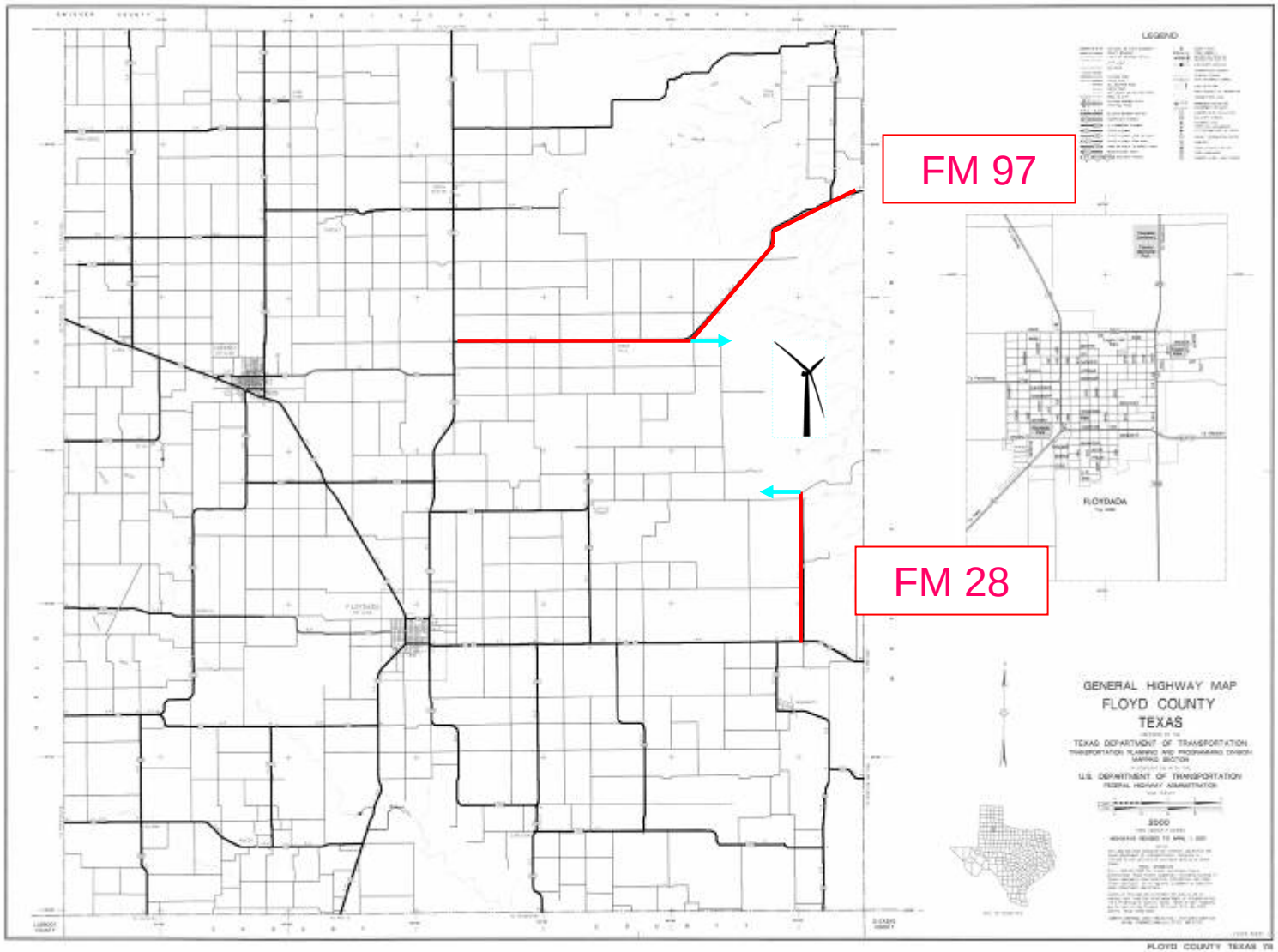


FLOYD COUNTY TEXAS 79


FM 97
FM 28
LEGEND
FLOYDADA
GENERAL HIGHWAY MAP
FLOYD COUNTY
TEXAS
TEXAS DEPARTMENT OF TRANSPORTATION
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
FLOYD COUNTY TEXAS

Farm to Market Road 97

- Built in 1949
- Load Zoned October 21, 1959 to maximum gross load of 58,420 lbs, (26,555 Kg)
- Load Zone removed in early 1980's allowing unrestricted loads of 80,000 lbs, (36,364 Kg)

Farm to Market Road 28

- Built in 1956
- Load Zoned October 21, 1959 to maximum gross load of 58,420 lbs, (26,555 Kg)
- Load Zone removed in early 1980's allowing unrestricted loads of 80,000 lbs, (36,364 Kg)

Wind Industry

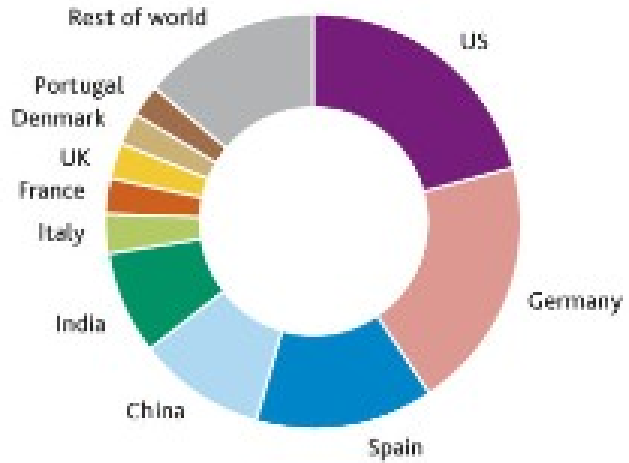
Magnitude of Issue

Global Top 10

total installed capacity as of 2008.

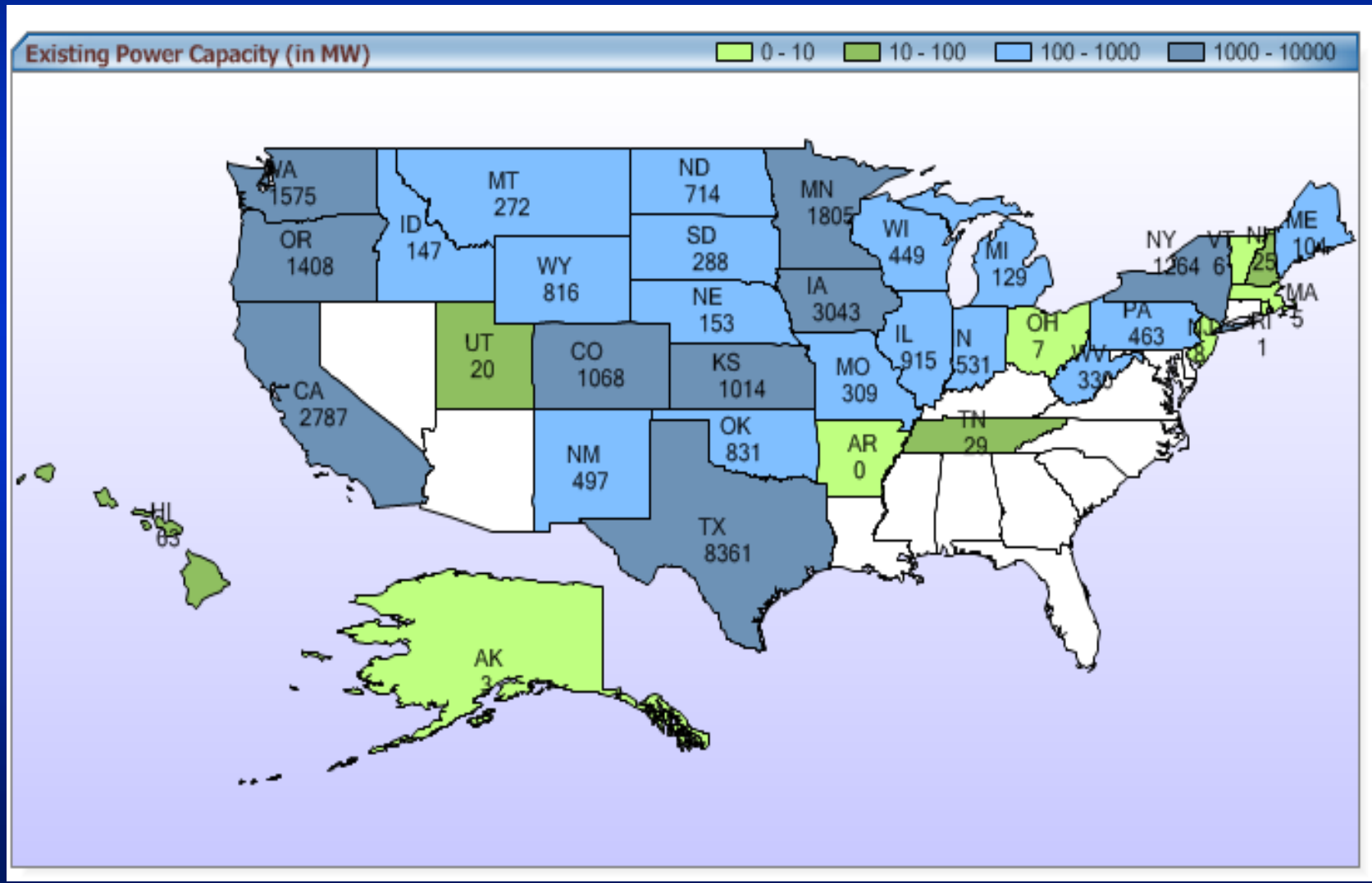
Source: www.gwec.net

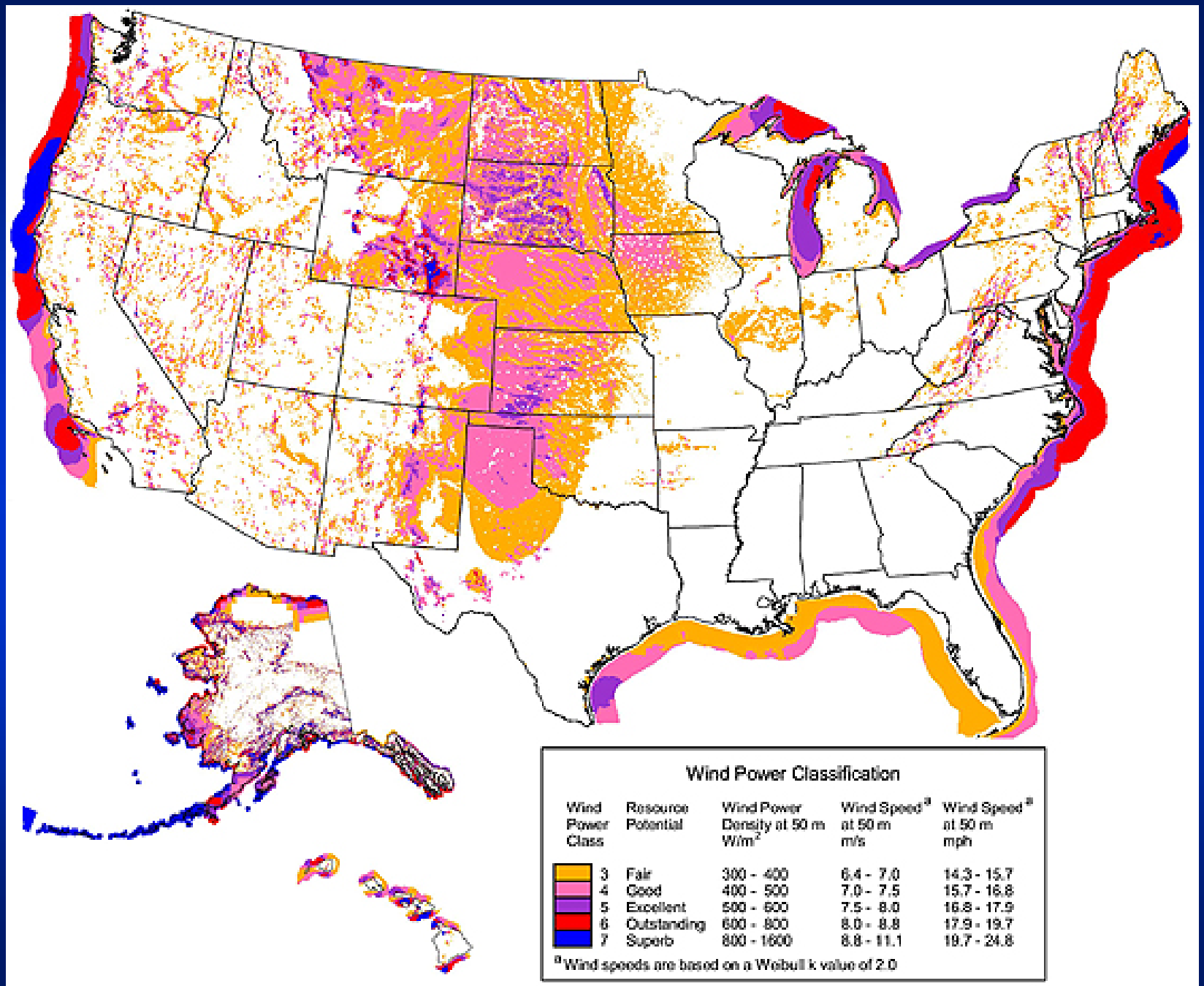
TOP 10 TOTAL INSTALLED CAPACITY 2008

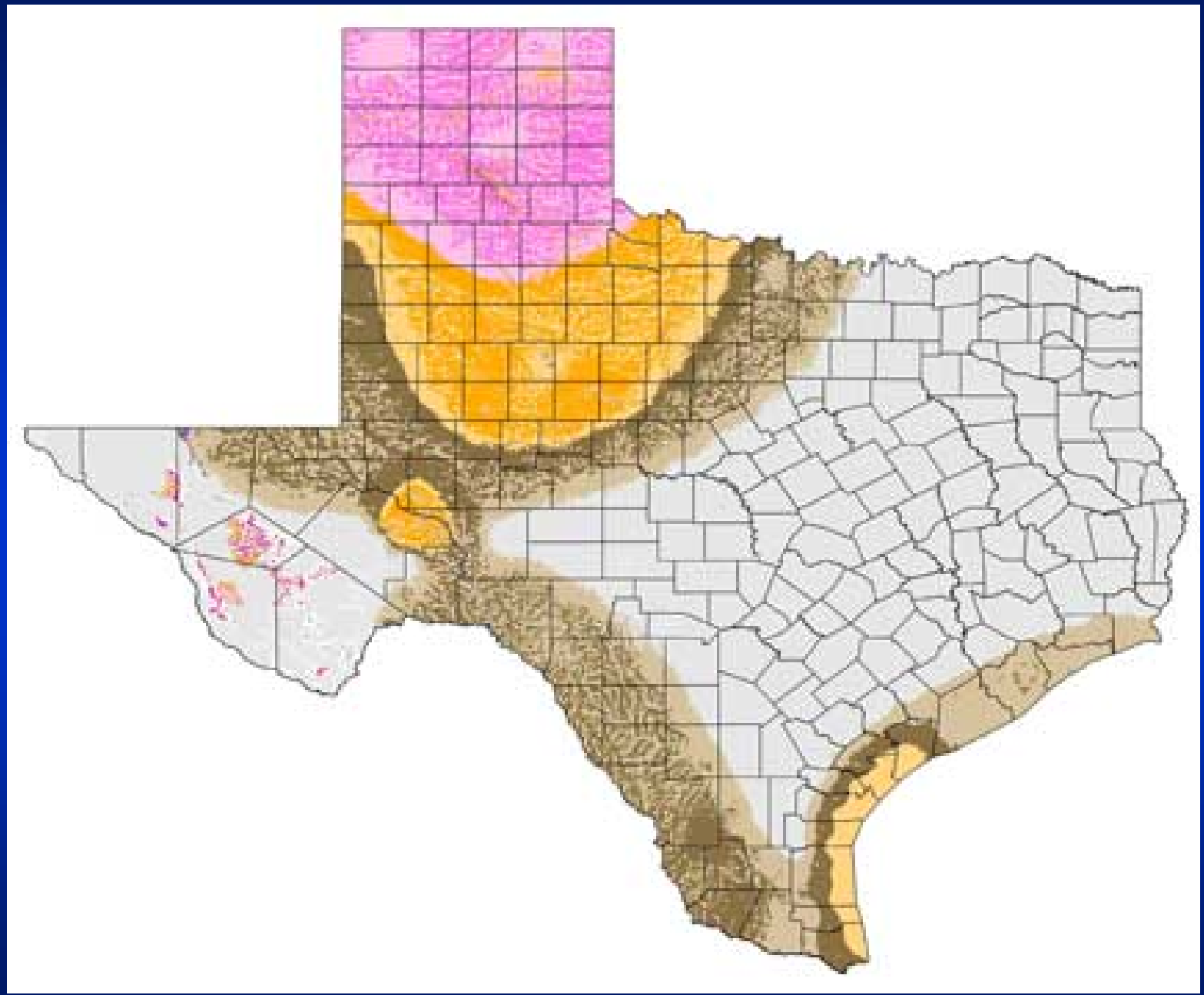


	MW	%
USA	25,170	20.8
Germany	23,903	19.8
Spain	16,754	13.9
China	12,210	10.1
India	9,645	8.0
Italy	3,736	3.1
France	3,404	2.8
UK	3,241	2.7
Denmark	3,180	2.6
Portugal	2,862	2.4
Rest of world	16,693	13.8
Total top 10	**104,104**	**86.2**
World total	**120,798**	**100.0**

Increase in Windfarm Installations
Installed US Capacity (MW)
as of 6/30/2008
www.awea.org




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
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



Texas Capacity (MW)

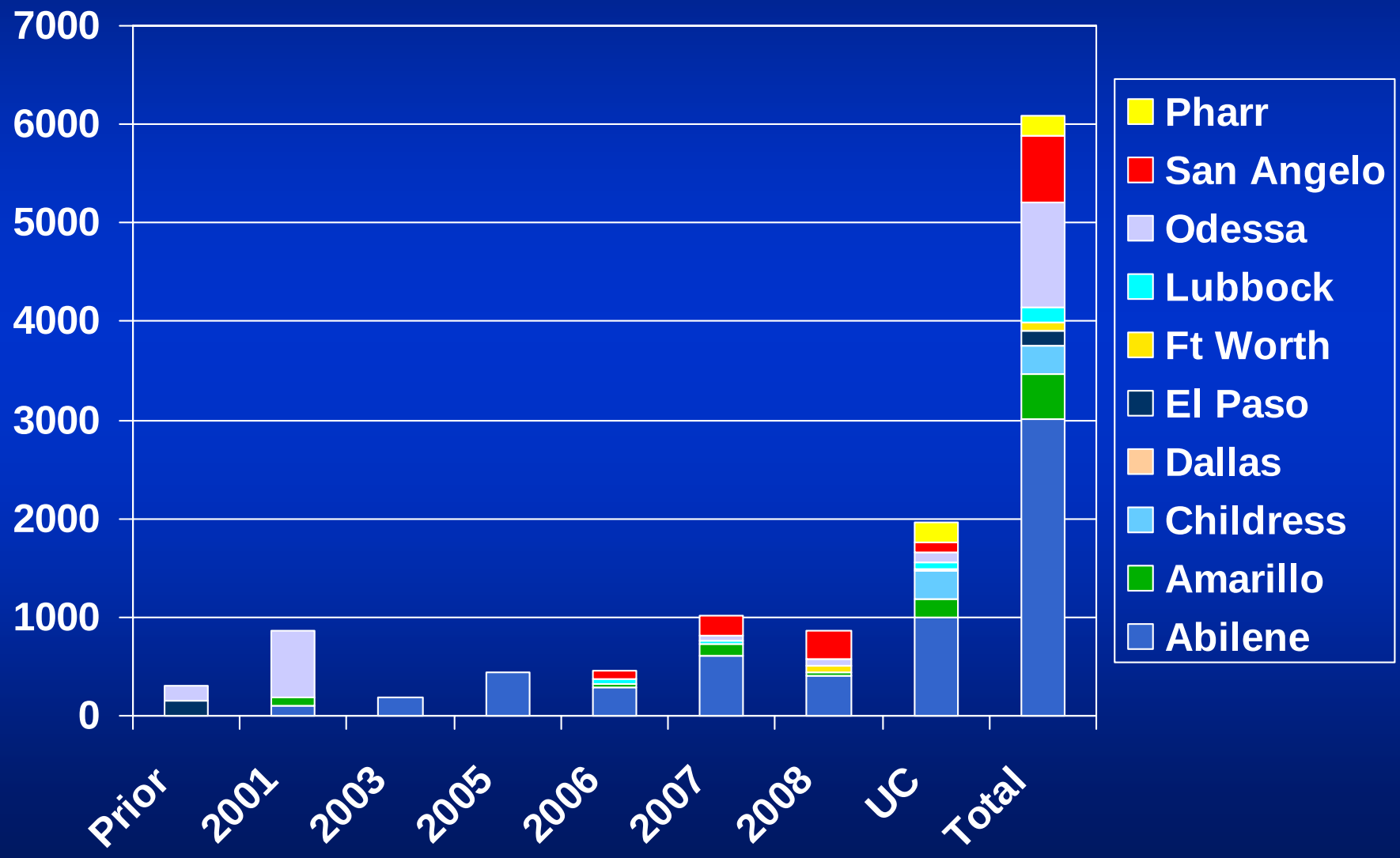
as of 6/30/2008

Districts	On Line '08	Under Const	2009-2012	Total
Abilene	3117.4	1491.2	2494.5	**7103.1**
Amarillo	483.4	263.5	5331.5	**6078.8**
Childress	0	330	3981.5	**4311.5**
Dallas	0.1	0	0	**0.1**
El Paso	71.1	0	0	**71.1**
Ft Worth	120.0	60	0	**180.0**
Lubbock	144.5	234	183	**561.5**
Odessa	1003.1	240.8	904	**2147.9**
San Angelo	957.5	182.1	788.5	**1928.1**
PHR/WAC/WFS	0	484.8	200/400	**1084.8**
Total MW	**5897.4**	**3286.4**	**14283.0**	**23466.8**
Units	4127	1966	~ 9522 *	15615

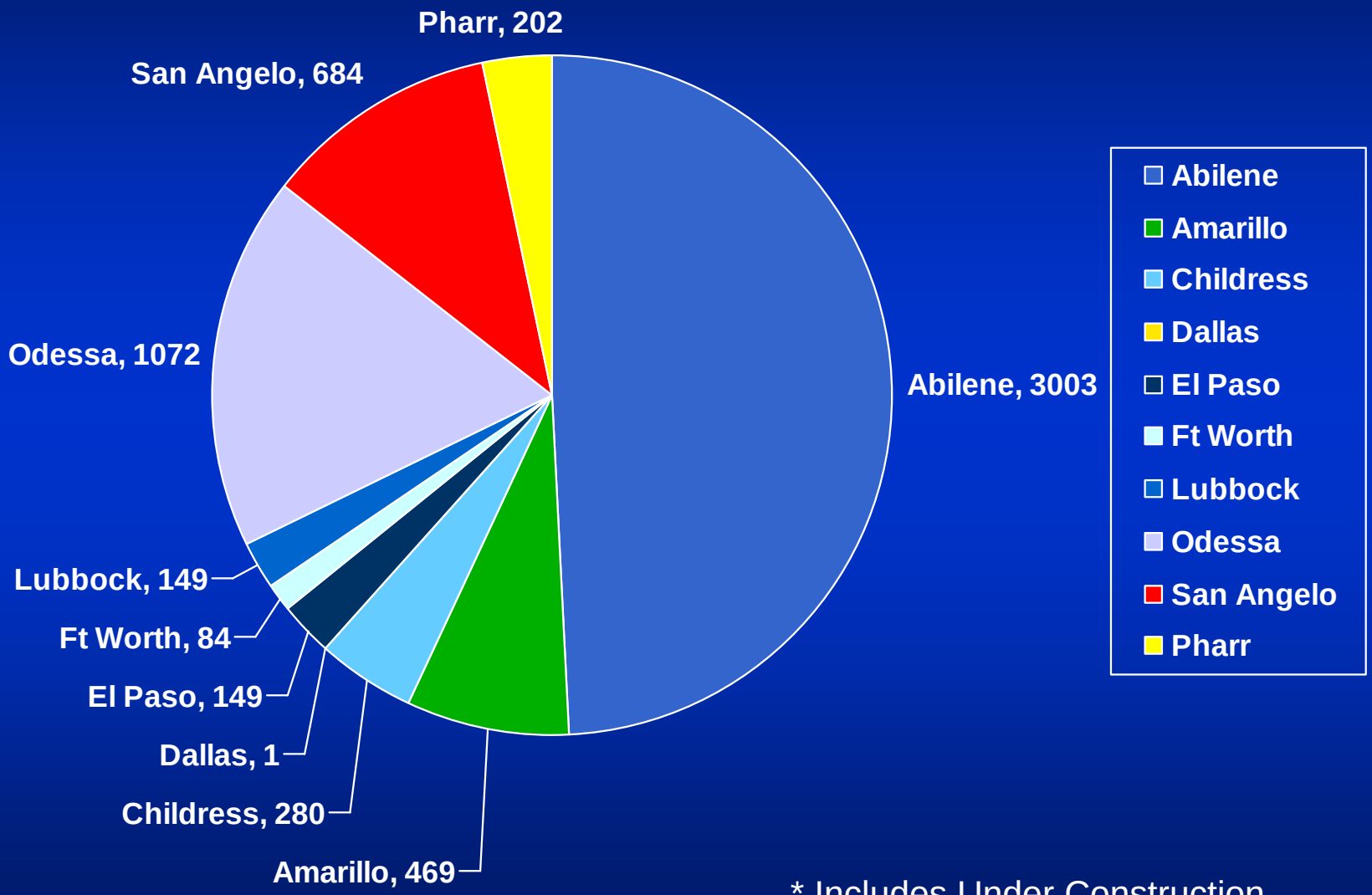
* Estimated 1.5 MW / unit

Texas Wind Turbine Units

as of 6/30/2008



Total Texas Wind Turbine Units



* Includes Under Construction

Sources of Potential Problems

1st question is:

How do Wind Generation Farms and roadways interact?

Sources of Potential Problems

Answer is:

Hauling of all the materials and equipment to the site for construction.

Sources of Potential Problems

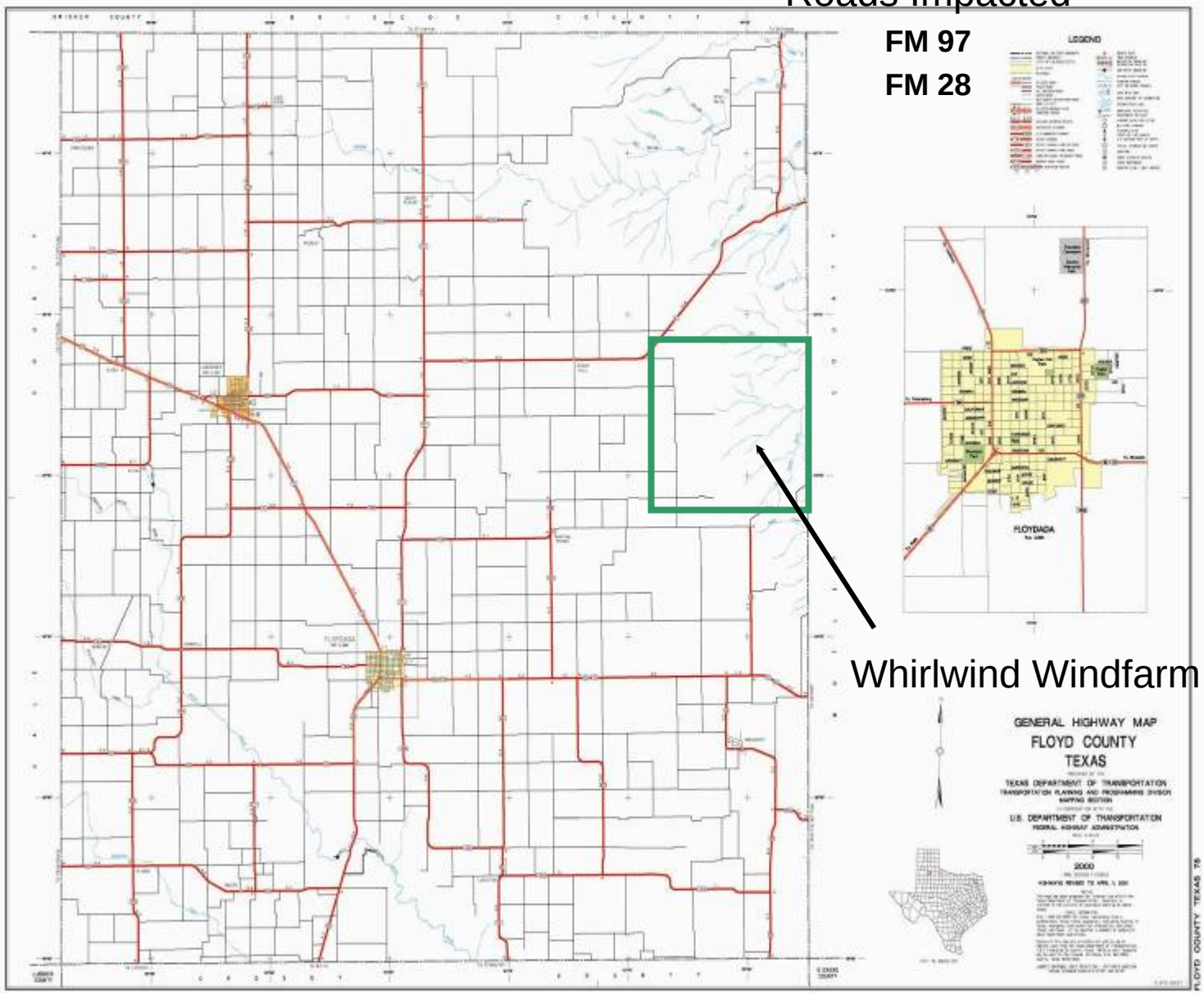
- Pavement structure
- Sub-grade soils
- Width of roadway
- Condition of existing roadway
- Rainfall

FLOYD COUNTY

Roads Impacted

FM 97

FM 28



Whirlwind Windfarm

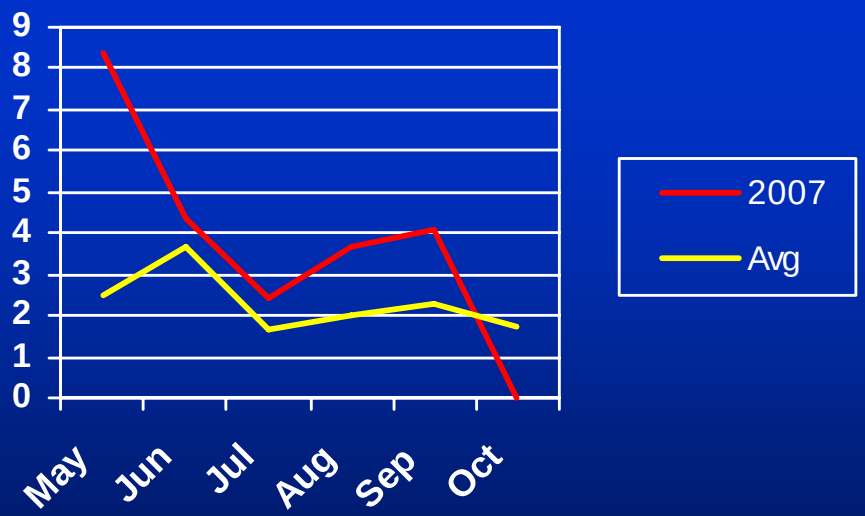
Assorted Problems

- Maintenance issues
  - broken edges
  - severe rutting
  - pavement failures
  - edge drop offs
  - bleeding pavement
  - sign issues at intersections
- Safety issues related to construction haul trucks:
  - unsafe work area when trucks hauling
  - speed of trucks - both loaded/unloaded
- Results
  - reduced PMIS scores
  - requires constant maintenance efforts
  - lack of funds to repair severely damaged roads

Contributing Factors for Maintenance Issues

- Above average rainfall during construction of site
- Pavement structure inadequate for loads
  - 2C surf treatment / 6” flex base / subgrade = sandy loams
- Narrow roads, built in ’50’s, no rehab other than seal coat
- Increase in trucks/day & ADT over short time span

Floyd County Rainfall



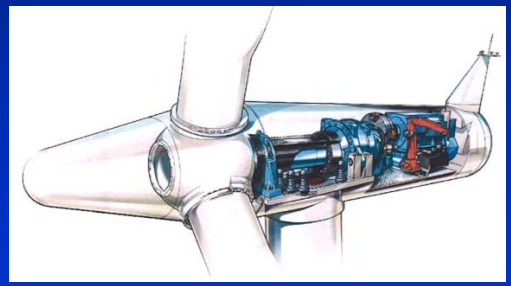
FM 97 in May after 8” rain

Wind Farm Site Details

Floyd County Whirlwind Site Renewable Energy Systems (RES) Construction Details

- 26 sites: 1-1/2 to 2 acres (1 ha) each
- Manufacturer: Seimens 2.3 MW units
- Site Construction: 12 mi (19 km) of caliche roadway @ 20’ (6 m) wide x 8” (20 cm) deep
- Hauled approximately 180,000 T (163,293 mg) caliche base material
- Hauled 6,000 CY (4,587 m^3) of oversize aggregate for playa lake bottoms
- Initial foundation excavation per site: 8’ (2 m) deep x 100’ (30 m) face/face

Wind Turbine Main Data



Siemens Mark II 2.3 MW Turbine

- Blade Length: 148 ft (45 m)
- Blade Weight: 26,456 lbs (12,000 kg)
- Nacelle Weight: 193,000 lbs (87,543 kg)
- Tower Weight: 358,033 lbs (162,401 kg)
- Tower Height: 262.5 ft (80 m)

Tower Sections

Actual Sizes:

Base: Ht - 52.8 ft.
Wt – 133.1K lbs
Diam – 14.1’ bot./13.1’ top

Mid: Ht – 89.7 ft.
Wt – 132K lbs
Diam – 13.1 ft.

Top: Ht – 118.2 ft.
Wt – 109.4 K lbs
Diam – 13.1’ bot./ 7.1’ top

Shipping sizes:

Base: Wt – 254K lbs
14’11” x 15’5” x 177’

Mid: Wt – 254K lbs
13’11” x 14’6” x 199’

Top: Wt – 213K-254K
13’11” x 14’6” x 199’

Nacelle

Actual Size:

Ht: 12.5 ft.
Width: 11.5 ft.
Length: 37.5 ft.
Weight: 193 K lbs

Shipping Size:

Wt: 385 K lbs
11’6” x 15’8” x 202’

Hub / Rotor Blades

Hub/Rotor:
Sweep area: 310.5 ft. diam
Wt: 63 K lbs

Blades:
Length: 148.4 ft.
Wt: 27.1K lbs
Spinner: 600 lbs

Rotor/blade assembly
Total wt: 144.8 K lbs
Speed of blade – 199 mph
@ 18 RPM

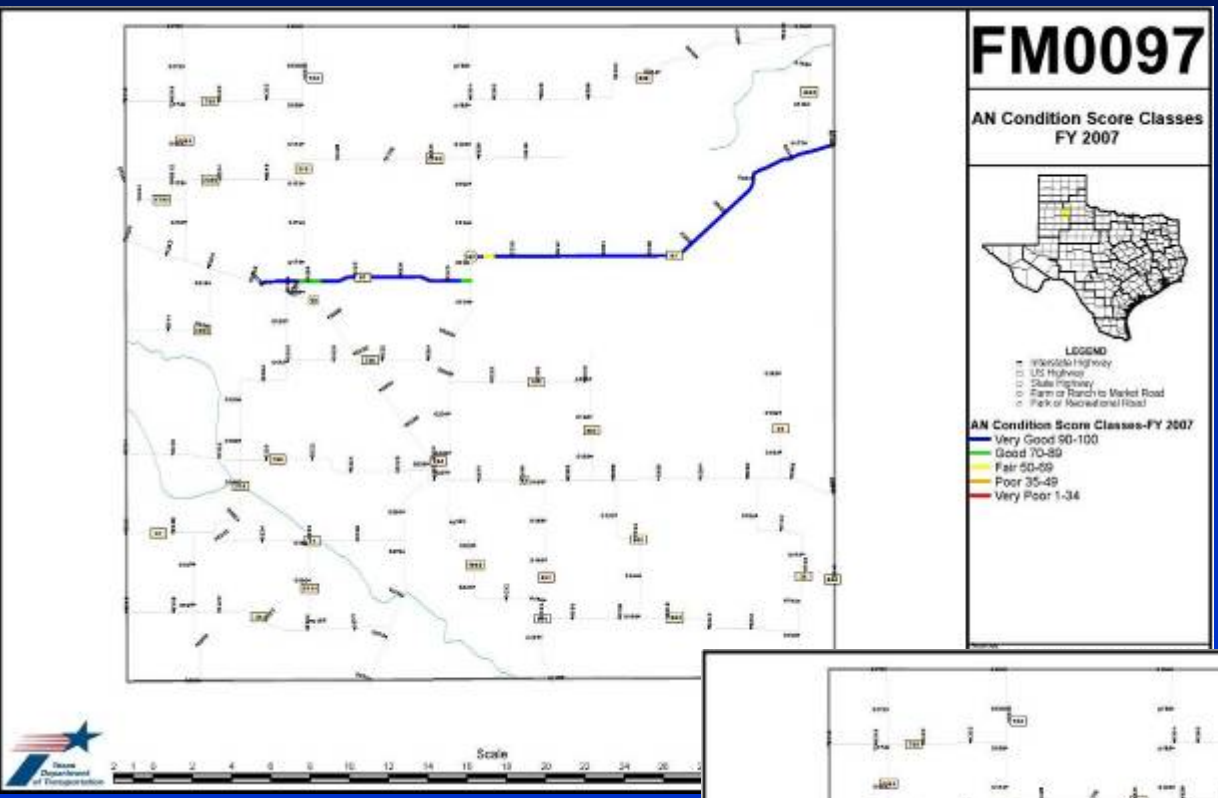
Ship Sizes:

Blades:
Weight: legal
legal x 14’6” x 185’

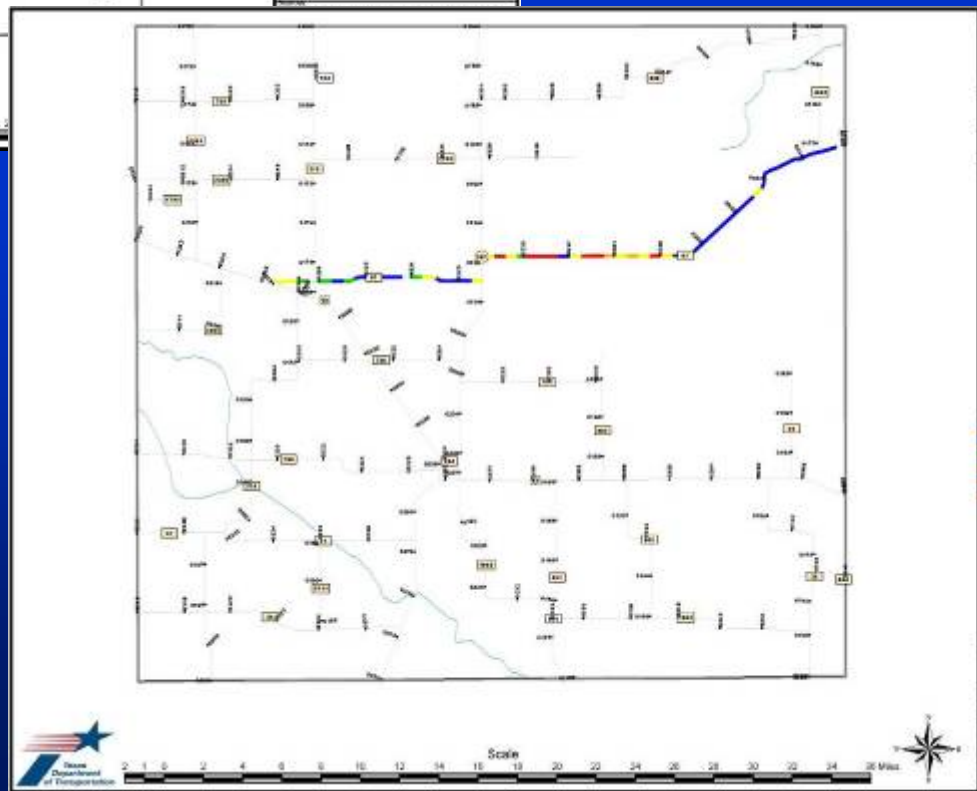
Total Wind Turbine Unit

- Power unit: 15.6 K lbs
- Misc accessories – 79.2 K lbs
- Tower weight w/ power unit & accessories – 806.8 K lbs
- Total foundation weight: 1.59 Mil lbs - 795 Tons
- Grand total = 1,245 Tons (1,129 Mg) each

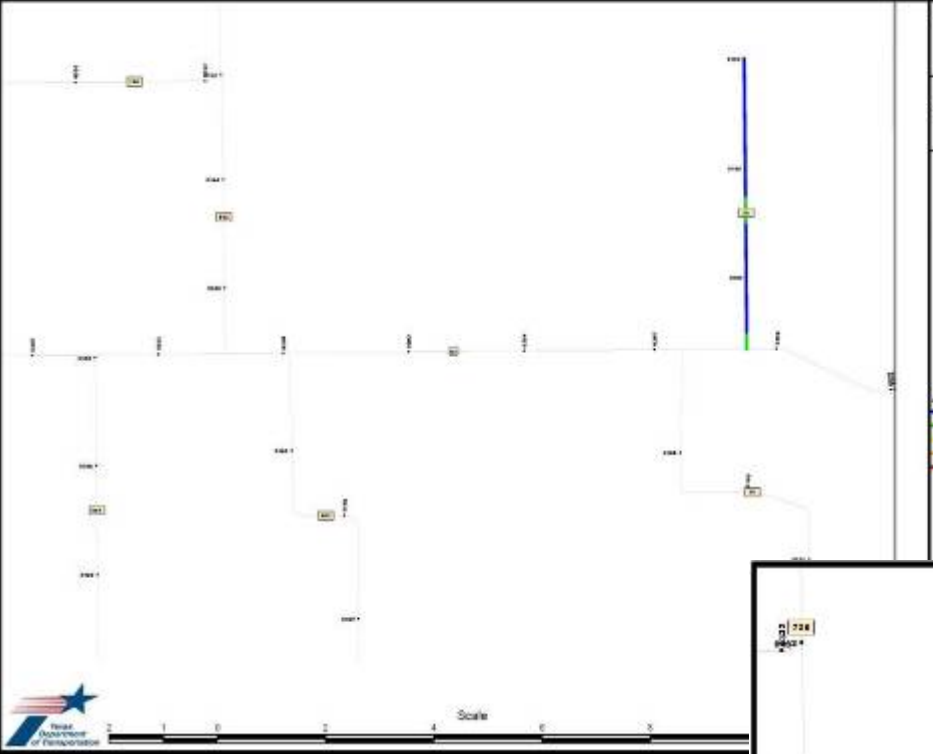
- Height to center of hub – 267 ft
- Height to top of blade – 422 ft
- Bolts: 160 – 1½" x 8 ft
- Hub sweep area – 310.5 ft diameter
- Speed at tip of blade – 199 mph



FM 97 Condition Score
in 2007 was
100 Avg

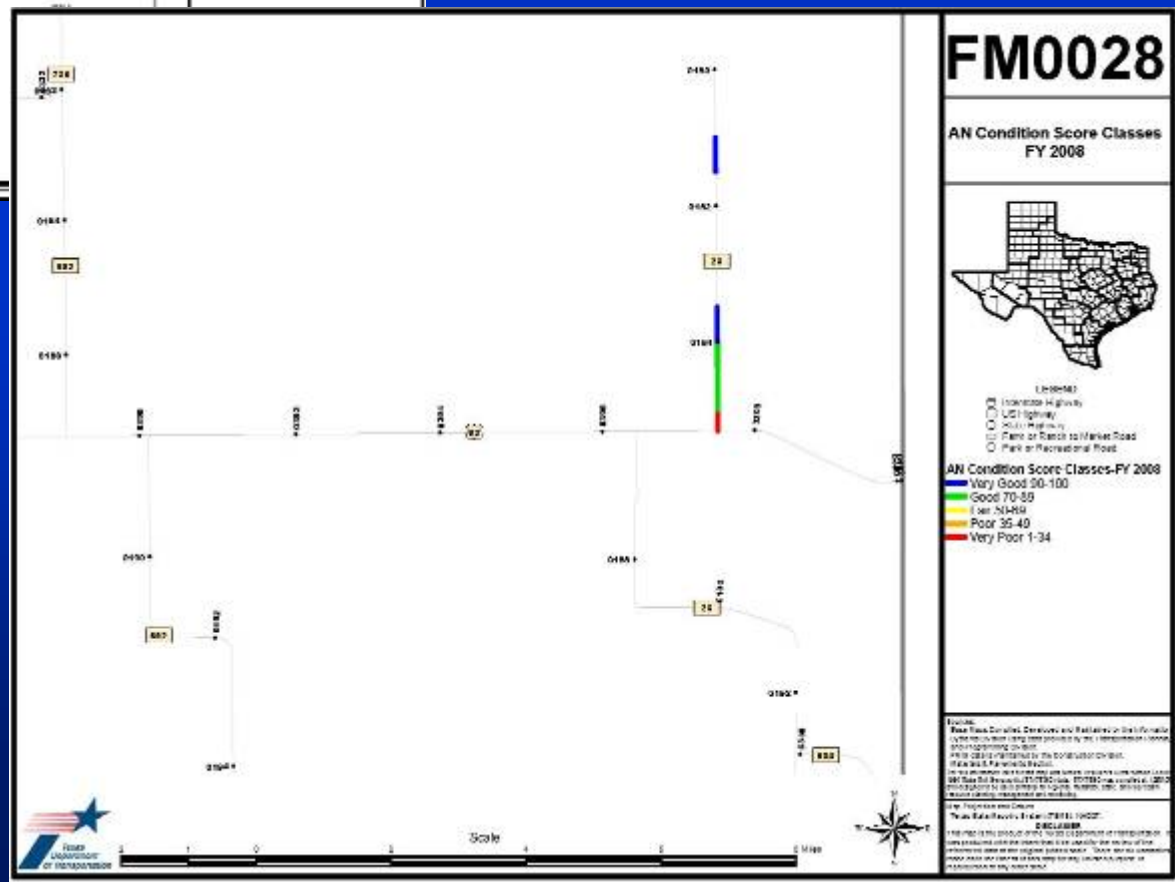


FM 97 Condition Score
In 2008 was
52 Avg

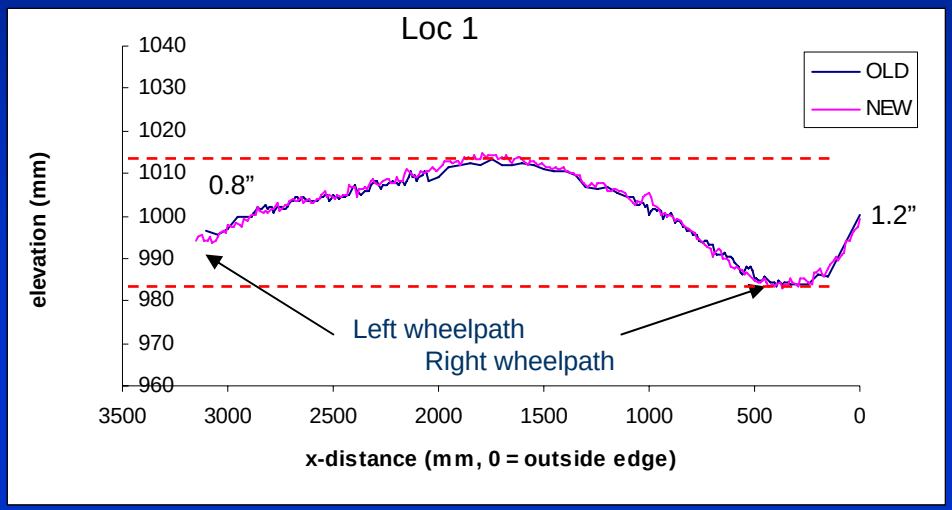


FM 28 Condition Score
in 2007 was
94 Avg

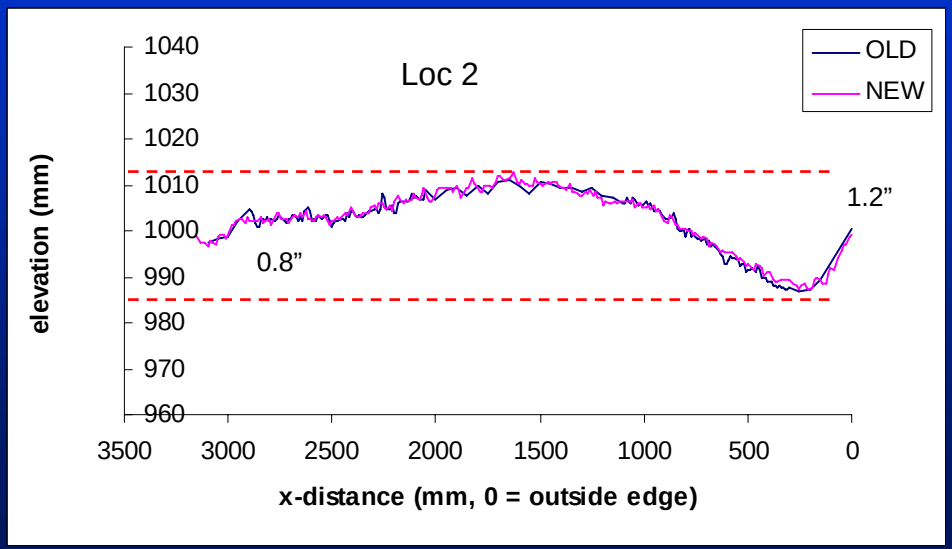
FM 28 Condition Score
In 2008 was
76 Avg

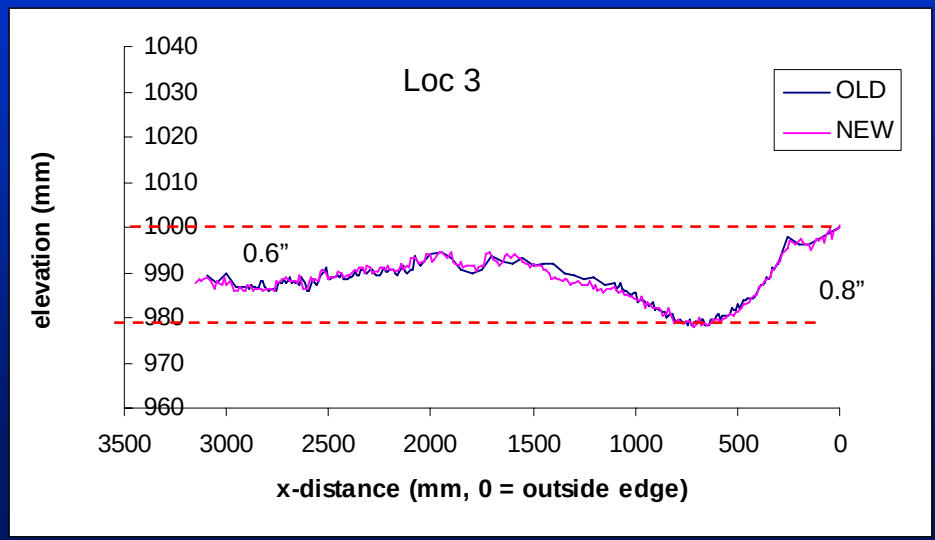


FM 97 Transverse Profile Results Rutting



- Old = July 11
- New = December 6
- No appreciable change in profiles
- Wheelpath rutting occurred prior July 11
  - Loc 1: LWP=0.8” RWP=1.2”
  - Loc 2: LWP=0.8” RWP=1.2”
  - Loc 3: LWP=0.6” RWP=0.8”





FM 28 Rutting / Base Failures

Transportation of Turbine Components to Site

Texas Projects

Wildorado (Cielo)
161.0 MW (70 WTG)
2006 & 2007

Whirlwind (RES)
Dougherty, TX
59.8 MW (26 WTG)
2007

Sweetwater 5 (RES)
105.8 MW (46 WTG)
2006

Forest Creek (Airtricity)
124.2 MW (54 WTG)
2006

Horse Hollow II (FPL)
299.0 MW (130 WTG)
2006

Wildhorse (Airtricity)
Paducah, Tx
75.9 MW (33 WTG)
2007

Foundation Preparation Details

Foundation Details

- Diameter: bottom – 56 ft.
  top – 17.2 ft.
- Overall Height: 8.5 ft.
- Rebar – 85,300 lbs.
- Cement – 350 cy
- Strength – 4500 psi


06/06/2007 09:25


06/16/2007 13:41


08/21/2007 15:53


Foundation/Crane pad
08/16/2007 08:27


08/28/2007 13:25


Crane pad is approximately size of football field
08/16/2007 08:15


09/26/2007 16:43


10/09/2007 17:43


10/09/2007 18:13

Nacelle Transport

Towers

Blades

WTG Erection Photos


#1
FM89


4 3:10 PM


4 2:47 PM

Conclusions

Based on observations in Lubbock District:

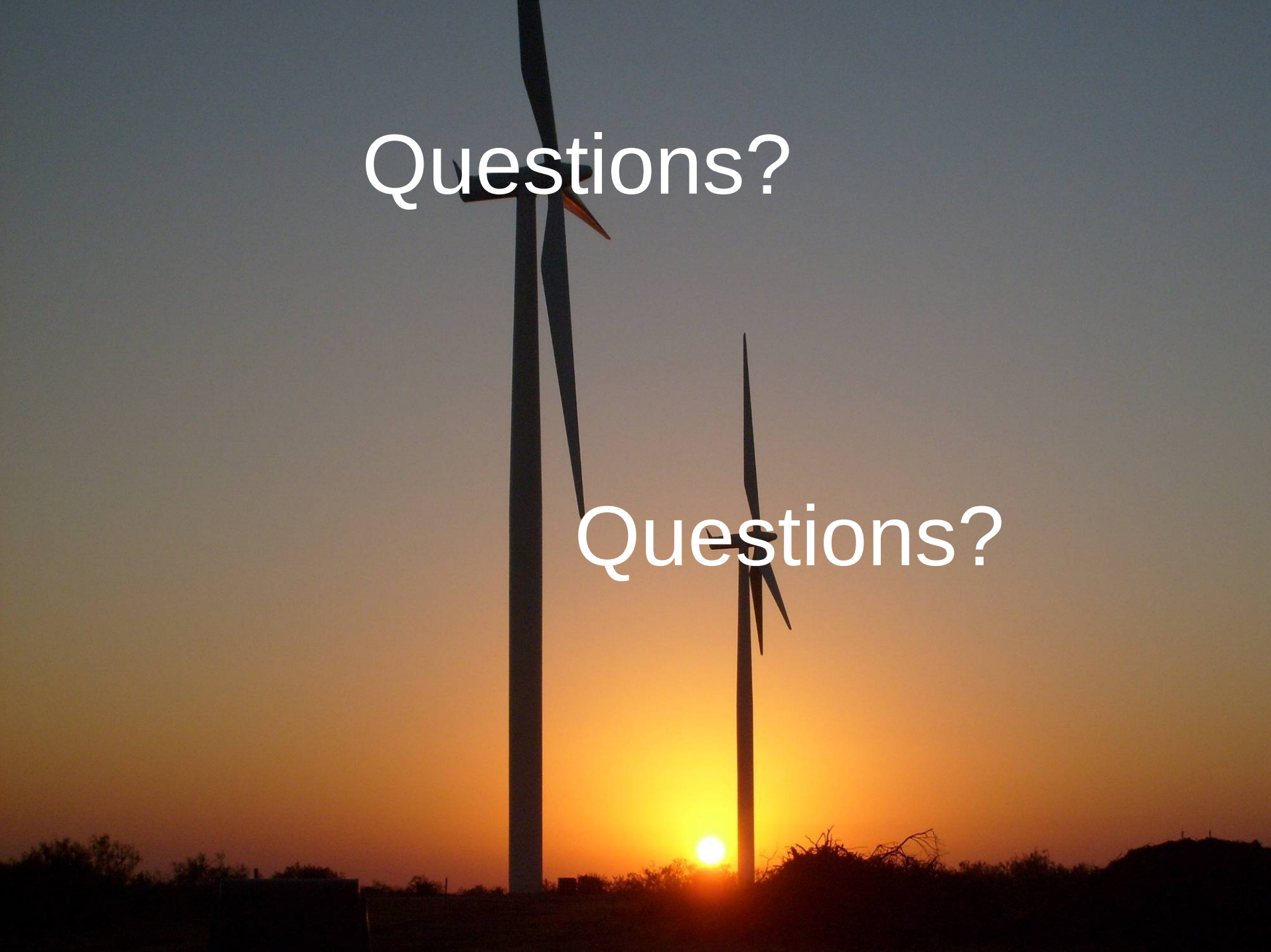
- Majority of pavement damage caused by haul trucks delivering construction materials to sites
- Rutting was not significantly impacted by the Over Size/Over Weight loads (turbines/cranes)
- Pavement structure was inadequate for wind power construction loads
- Excessive moisture was a contributing factor

Recommendations
(…in an ideal world…)

- Early knowledge of planned windfarm is key
- Work with the developer
  - Determine impact (size, duration, expansion)
  - Obtain schedule of construction/expansion
  - Address safety concerns
  - Mitigate damages
- Reduce maintenance burden by minimizing impact to as few roads as possible

RES project to include 59 turbines

Newspaper article from Floyd County, September 9, 2008, announcing 59 new wind turbines to be up and running by the end of 2010.


Questions?
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