Developing a Hybrid Solar/Wind Powered Irrigation System for Crops in the Great Plains

Brian Vick, P.E.
USDA-Agricultural Research Service
Conservation & Production Research Lab
Bushland, Texas

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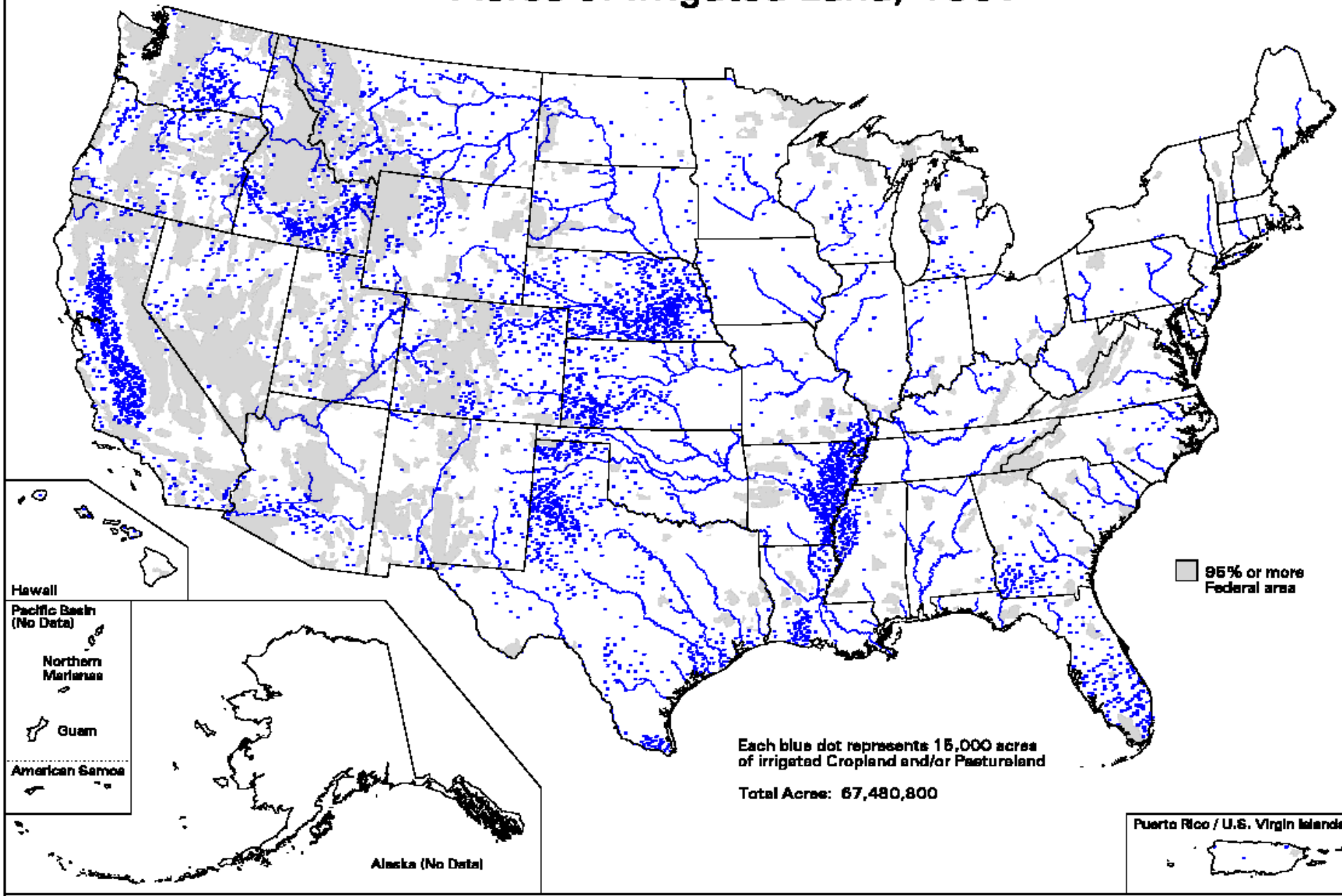
Great Plains of United States

Acres of Irrigated Land, 1997



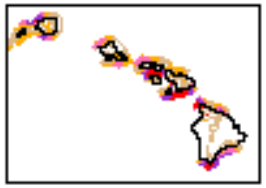
USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service
Resource Assessment Division
Washington DC January 2001

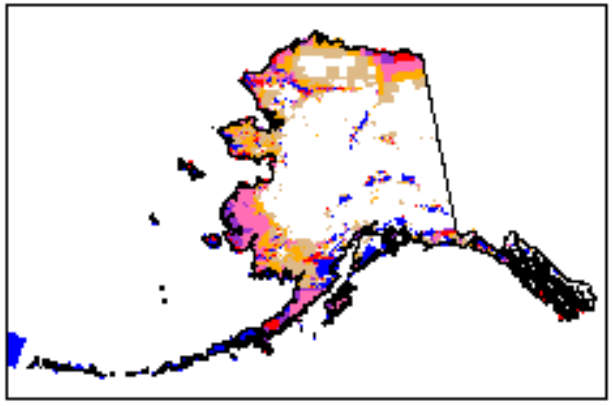
Map ID: m5297
For proper interpretation, see Explanation of Analysis for this map at our web site. Search for "USDASOTL" to locate our map index.

Data Source: 1997 National Resources Inventory
Revised December 2000

United States - Wind Resource Map

This map shows the annual average wind power estimates at 50 meters above the surface of the United States. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.





Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed* at 50 m m/s	Wind Speed* 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

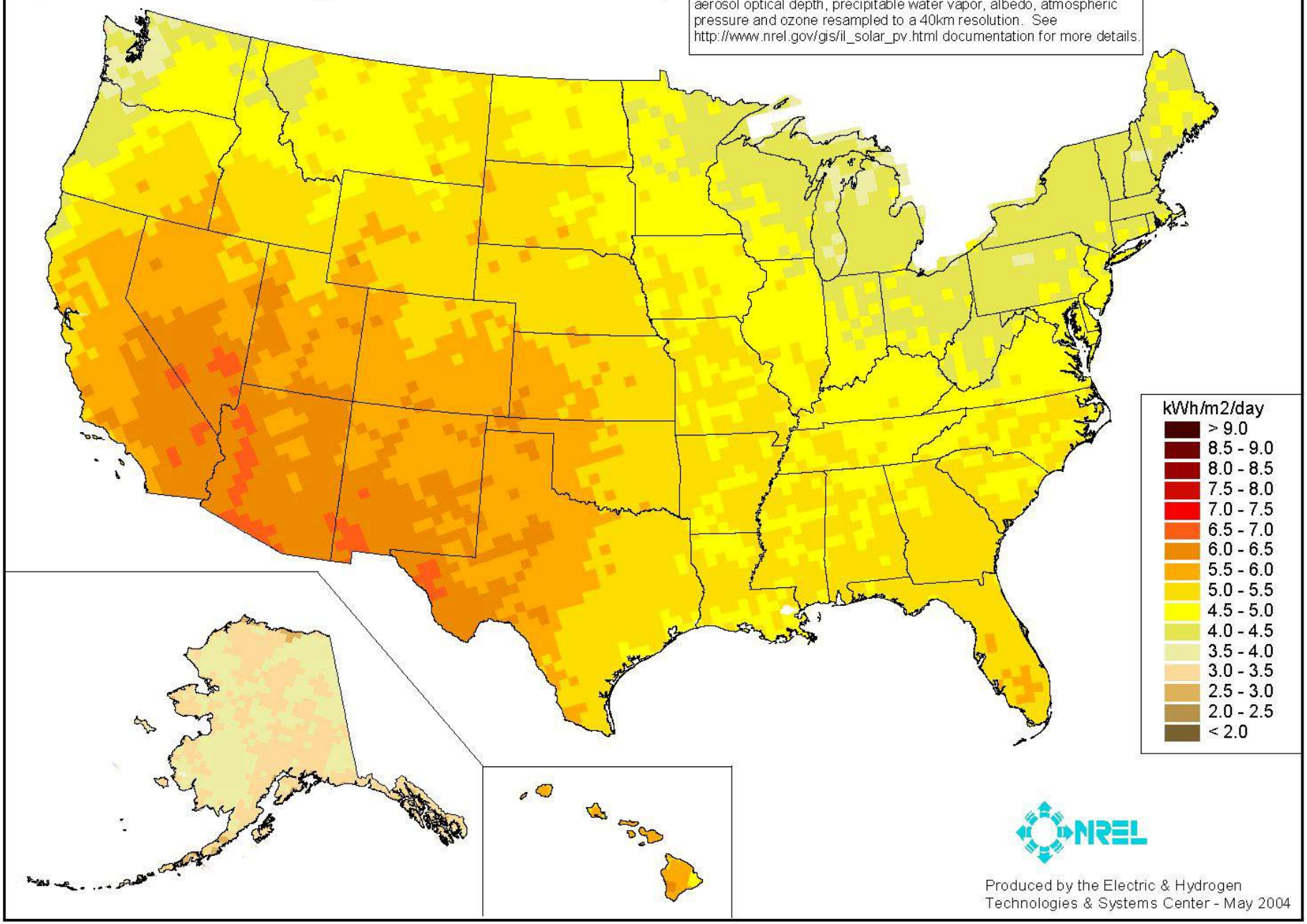
*Wind speeds are based on a Weibull k value of 2.0

U.S. Department of Energy
National Renewable Energy Laboratory

PV Solar Radiation
(Flat Plate, Facing South, Latitude Tilt)

Annual

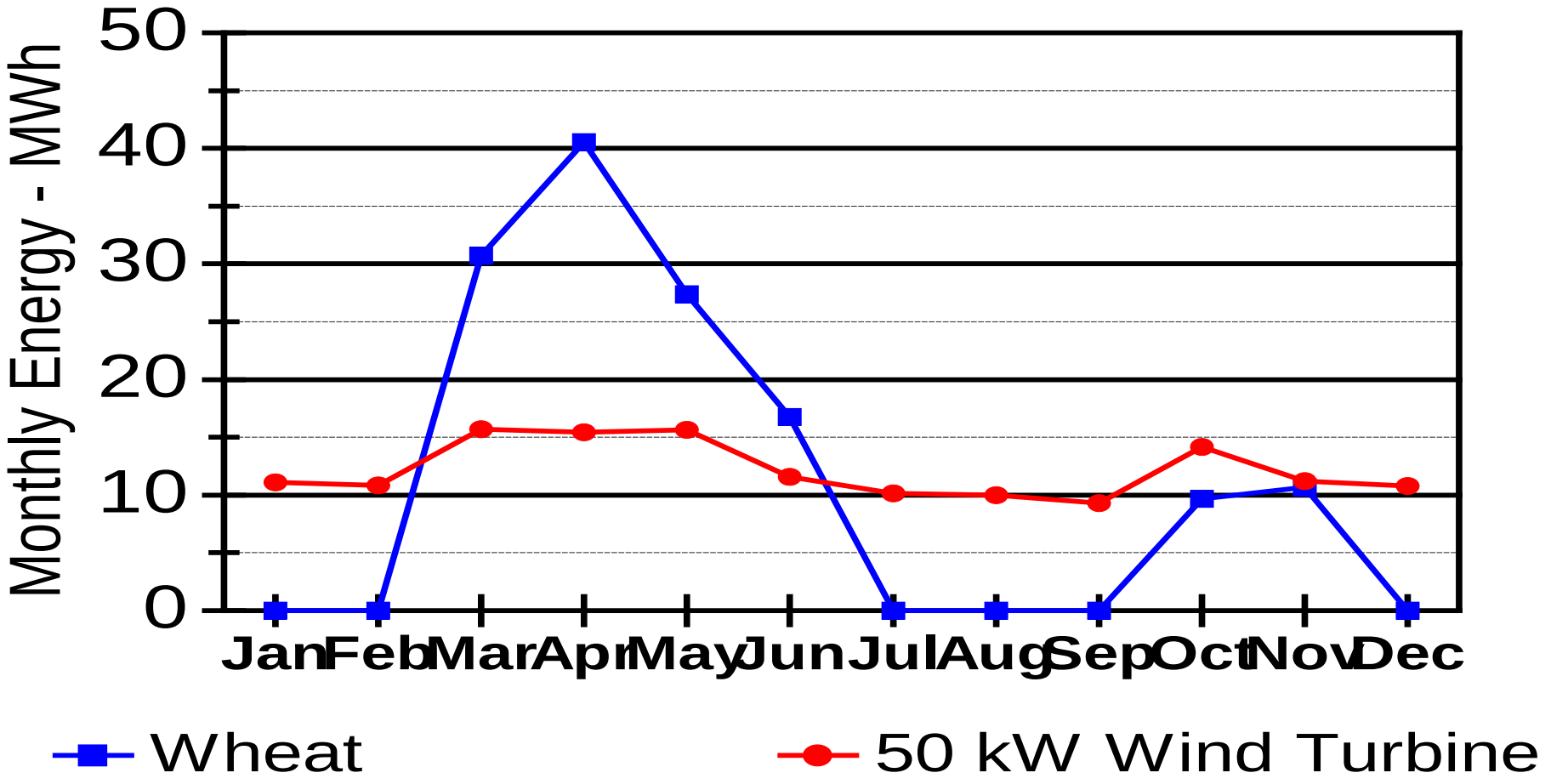
Model estimates of monthly average daily total radiation using inputs derived from satellite and/or surface observations of cloud cover, aerosol optical depth, precipitable water vapor, albedo, atmospheric pressure and ozone resampled to a 40km resolution. See http://www.nrel.gov/gis/il_solar_pv.html documentation for more details.



NREL

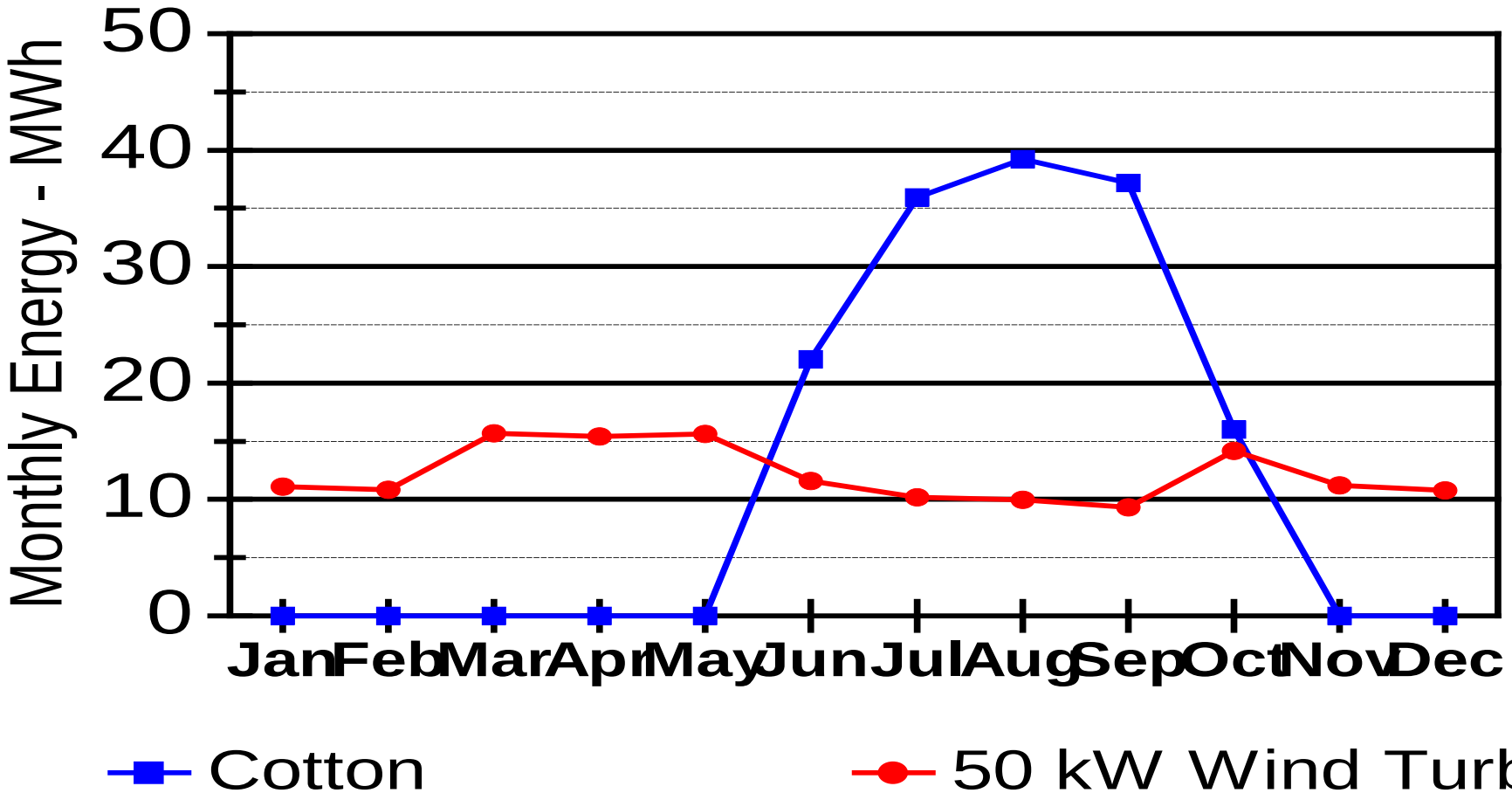
Produced by the Electric & Hydrogen Technologies & Systems Center - May 2004

Irrigating Wheat (51 ha)
50 kW wind turb. (25m hub



Note: Texas Panhandle, Center Pivot,
1 acre-inch requires 62 kWh of energy.

Irrigating Cotton (51 ha)
50 kW Wind Turbine (25m hu



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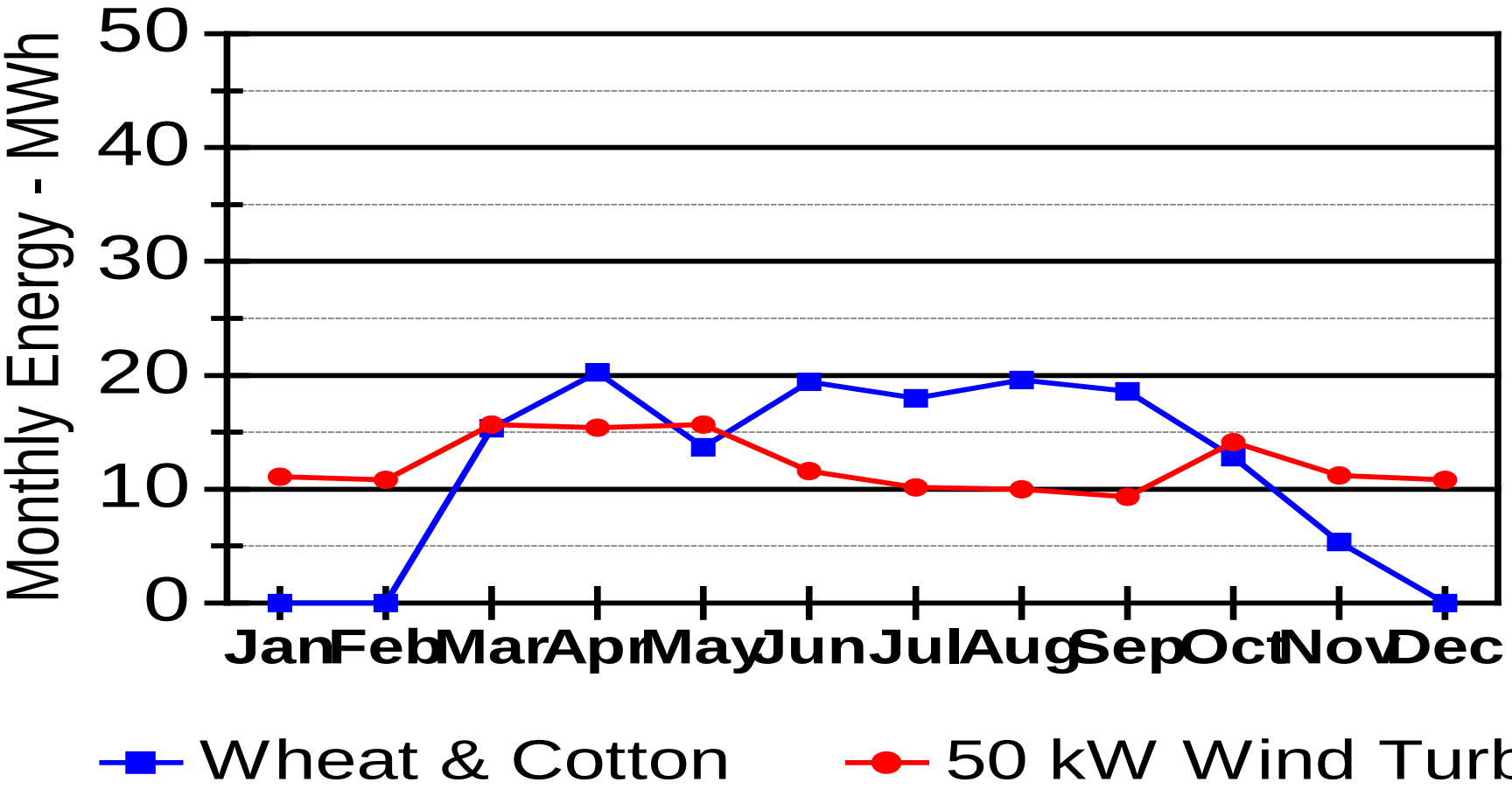
Irrigating Wheat & Cotton (51
50 kW Wind Turbine (25m hu



Note: Texas Panhandle, Center Pivot,
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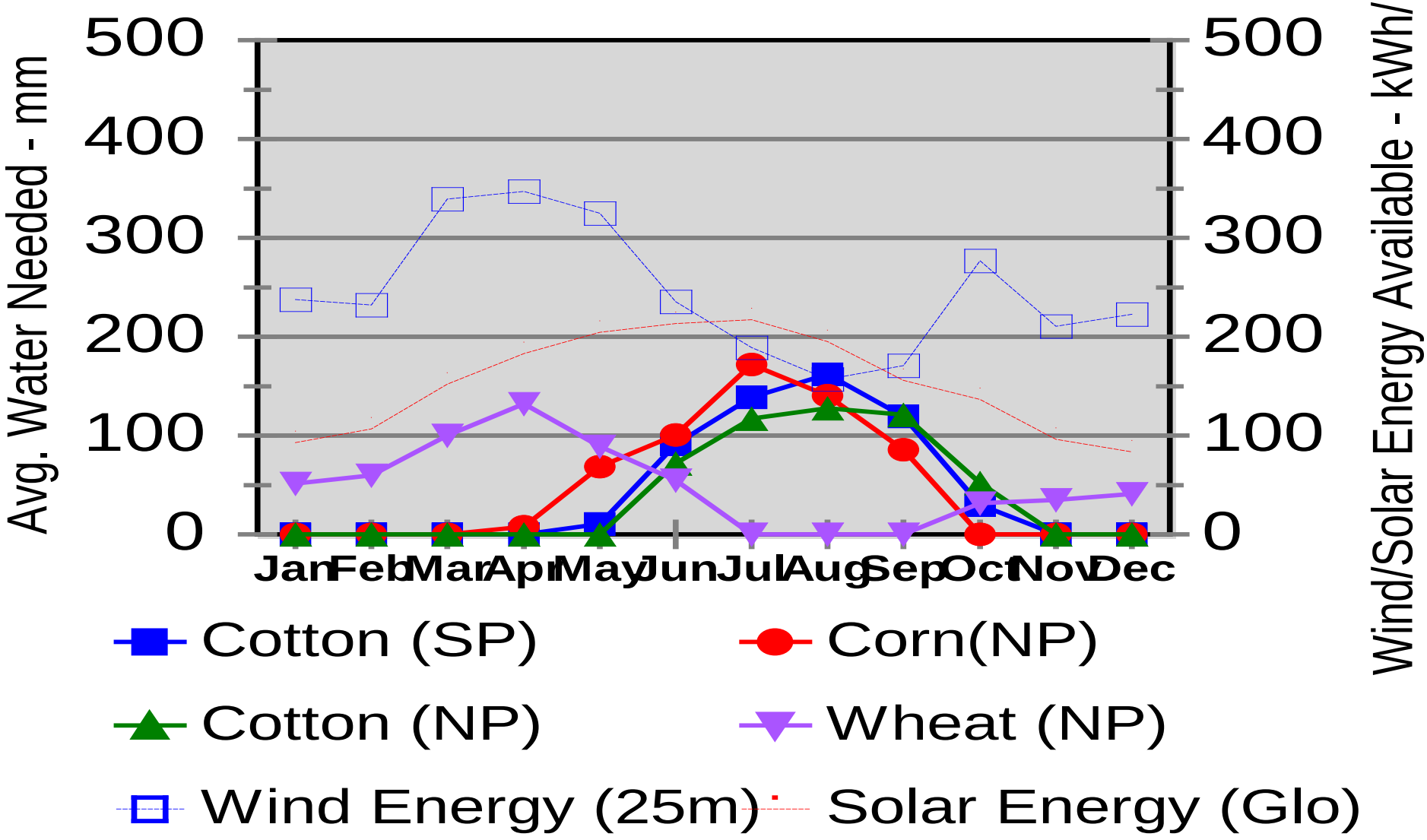
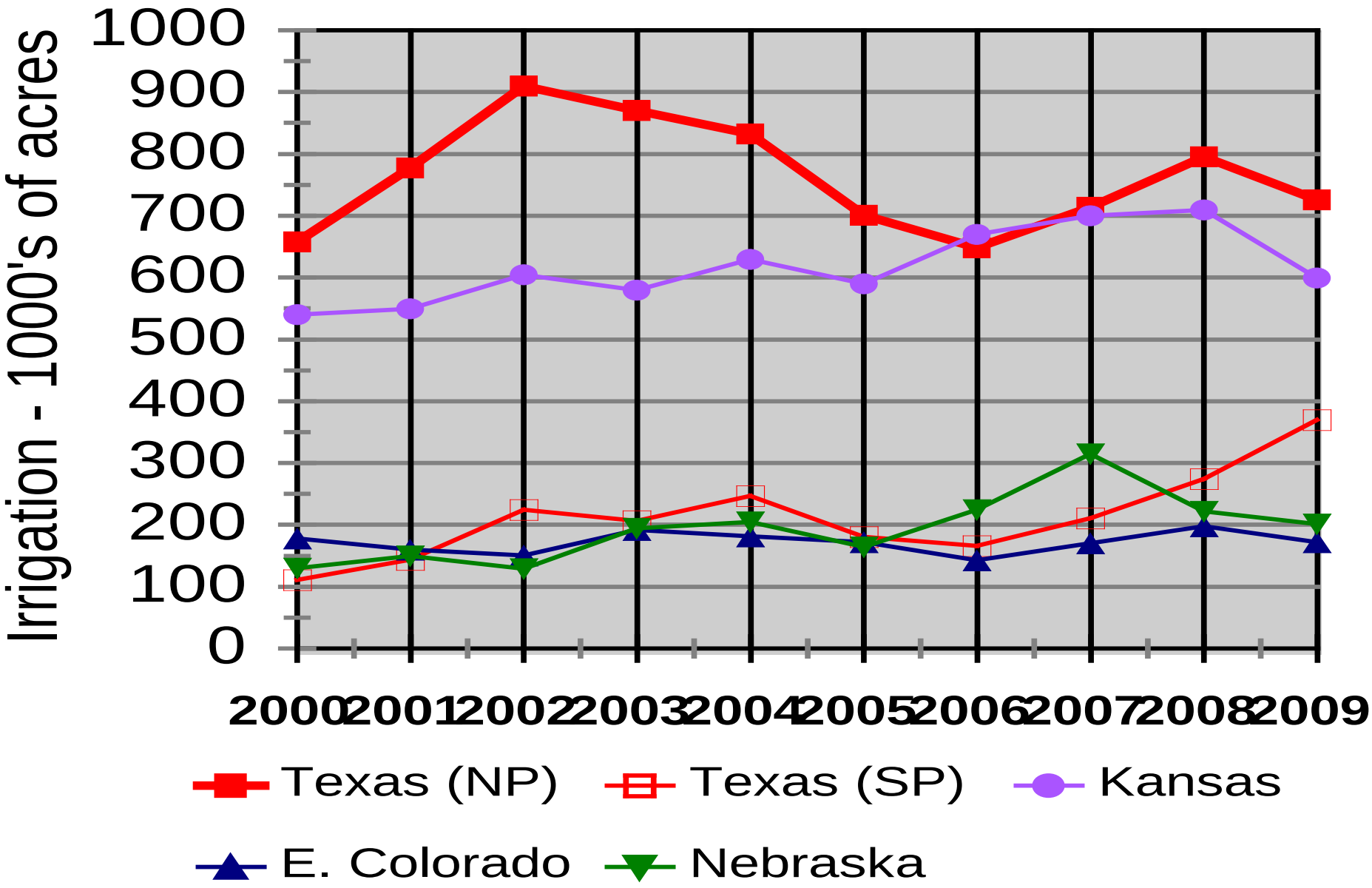
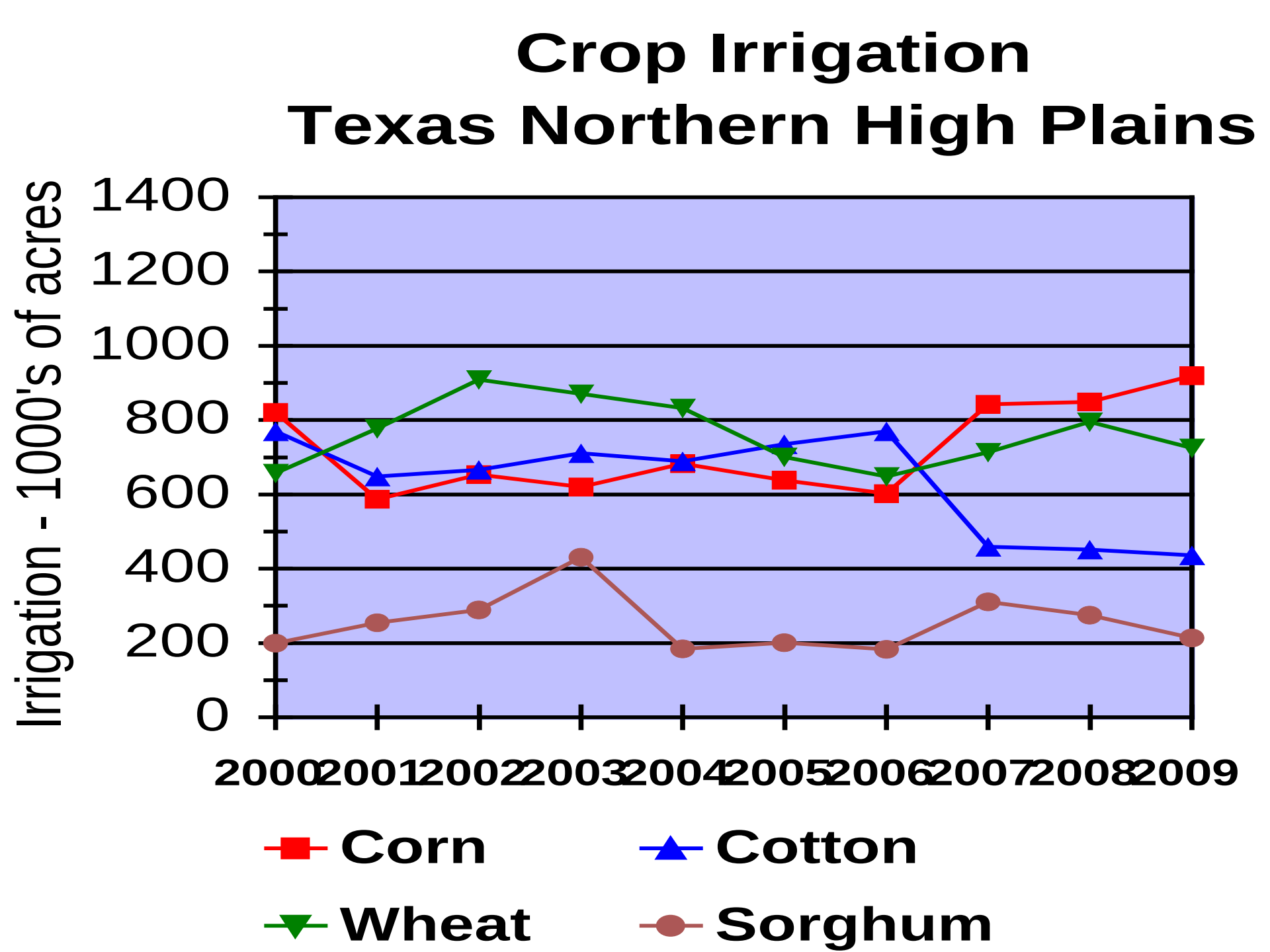
Average Irrigation Water Required & Wind/Solar Energy Available



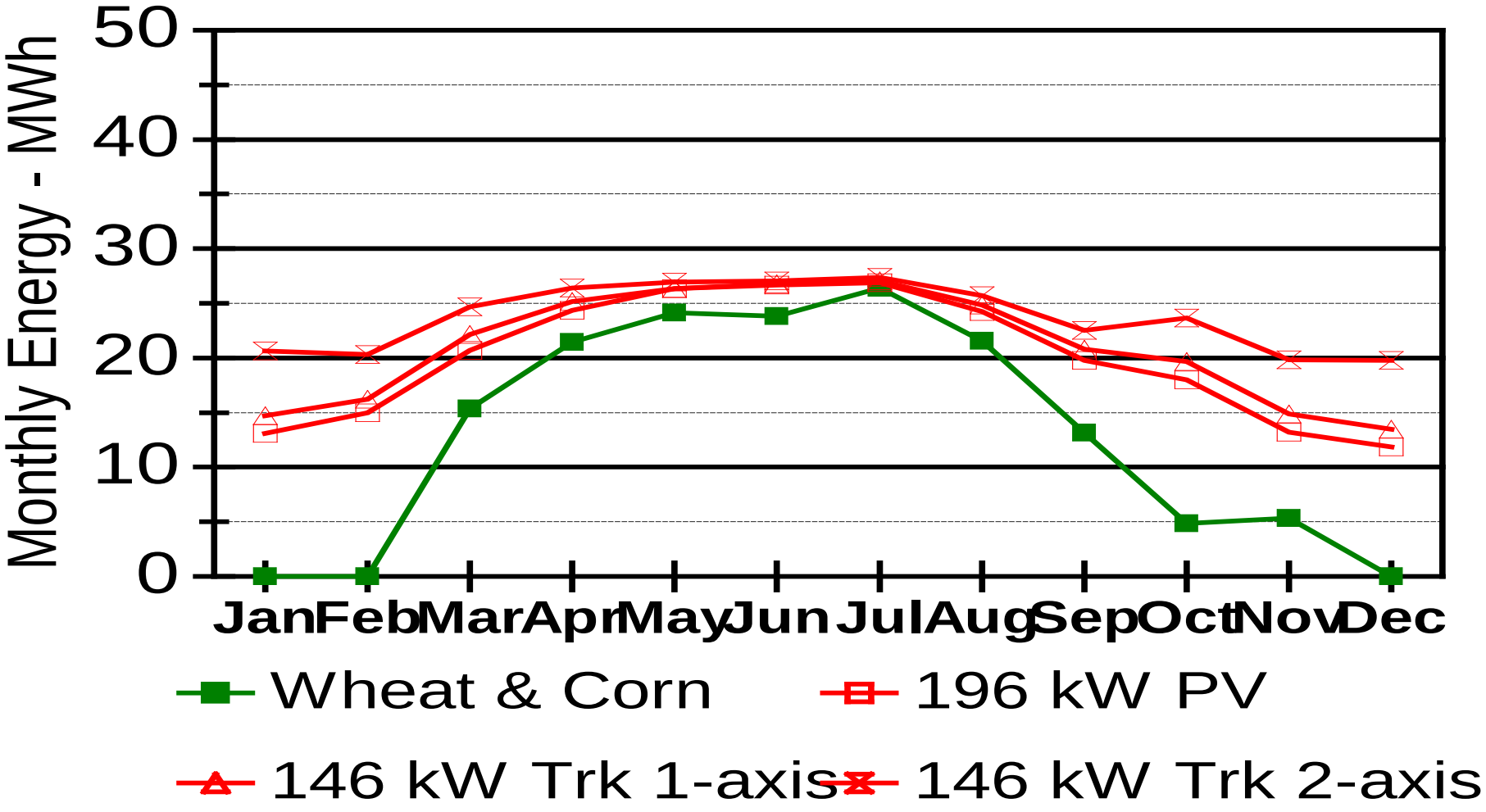
SP-Southern High Plains of TX, NP-Northern High Plains of T

Irrigated Winter Wheat



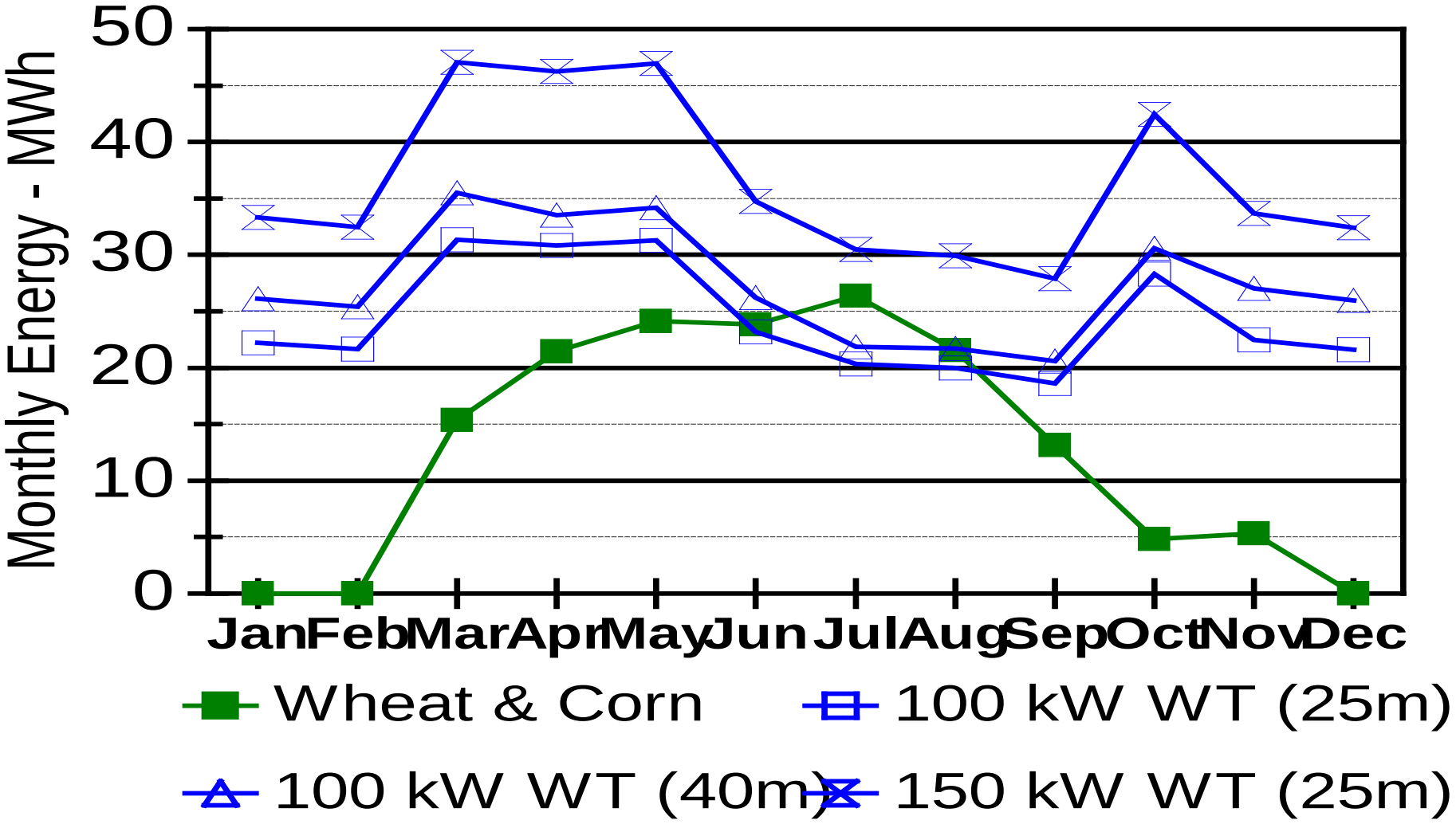

Crop Irrigation
Texas Northern High Plains
Irrigation - 1000's of acres
1400
1200
1000
800
600
400
200
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Corn
Cotton
Wheat
Sorghum

Irrigating Wheat & Corn (51
with Solar PV Arrays



Note: Texas Panhandle, Center Pivot,
1 acre-inch requires 62 kWh of energy.

Irrigating Wheat & Corn (51 ha with Wind Turbines



Note: Texas Panhandle, Center Pivot,
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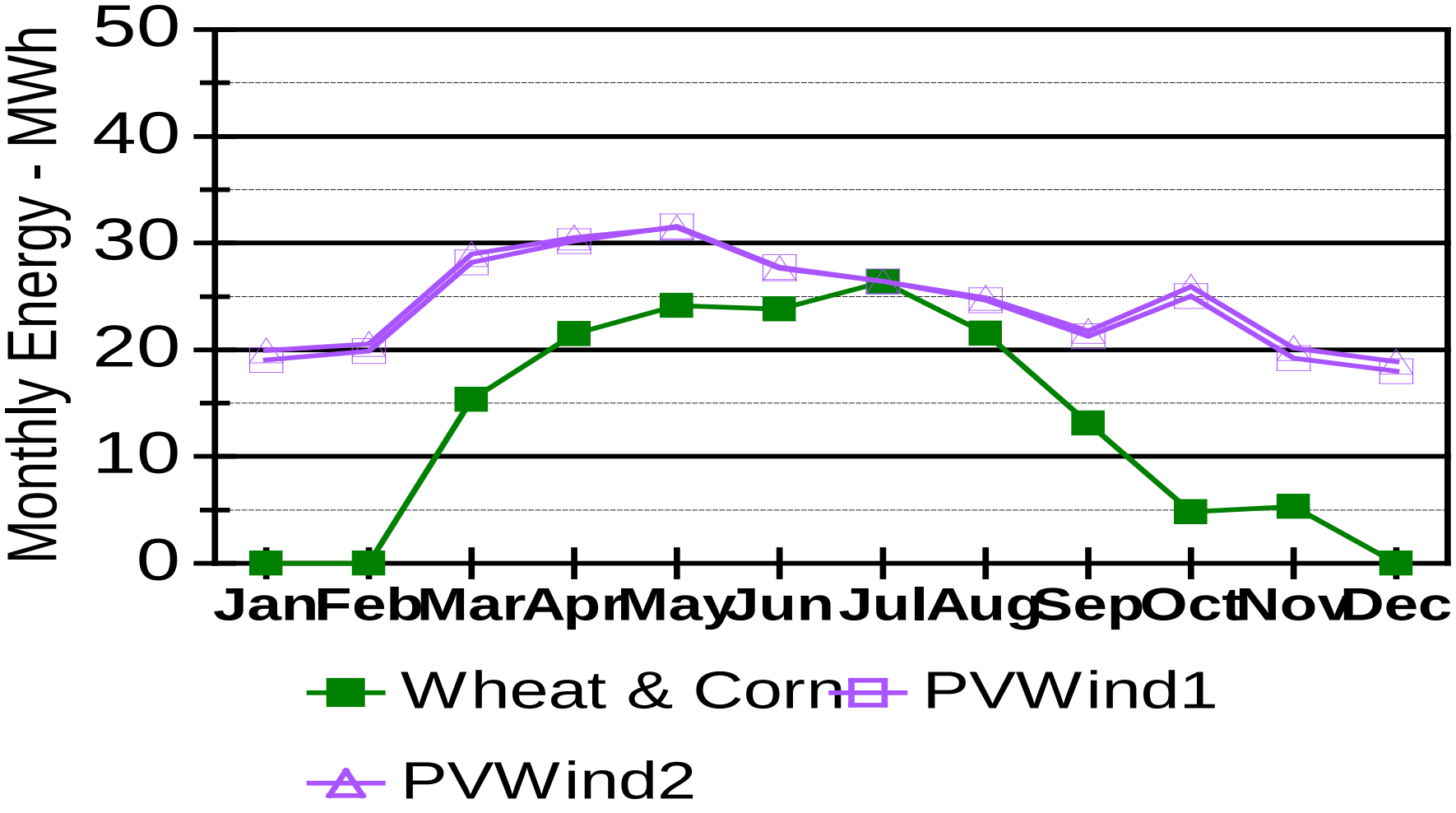
Irrigating Wheat & Corn (51 ha) with PV Array and Wind Turbine

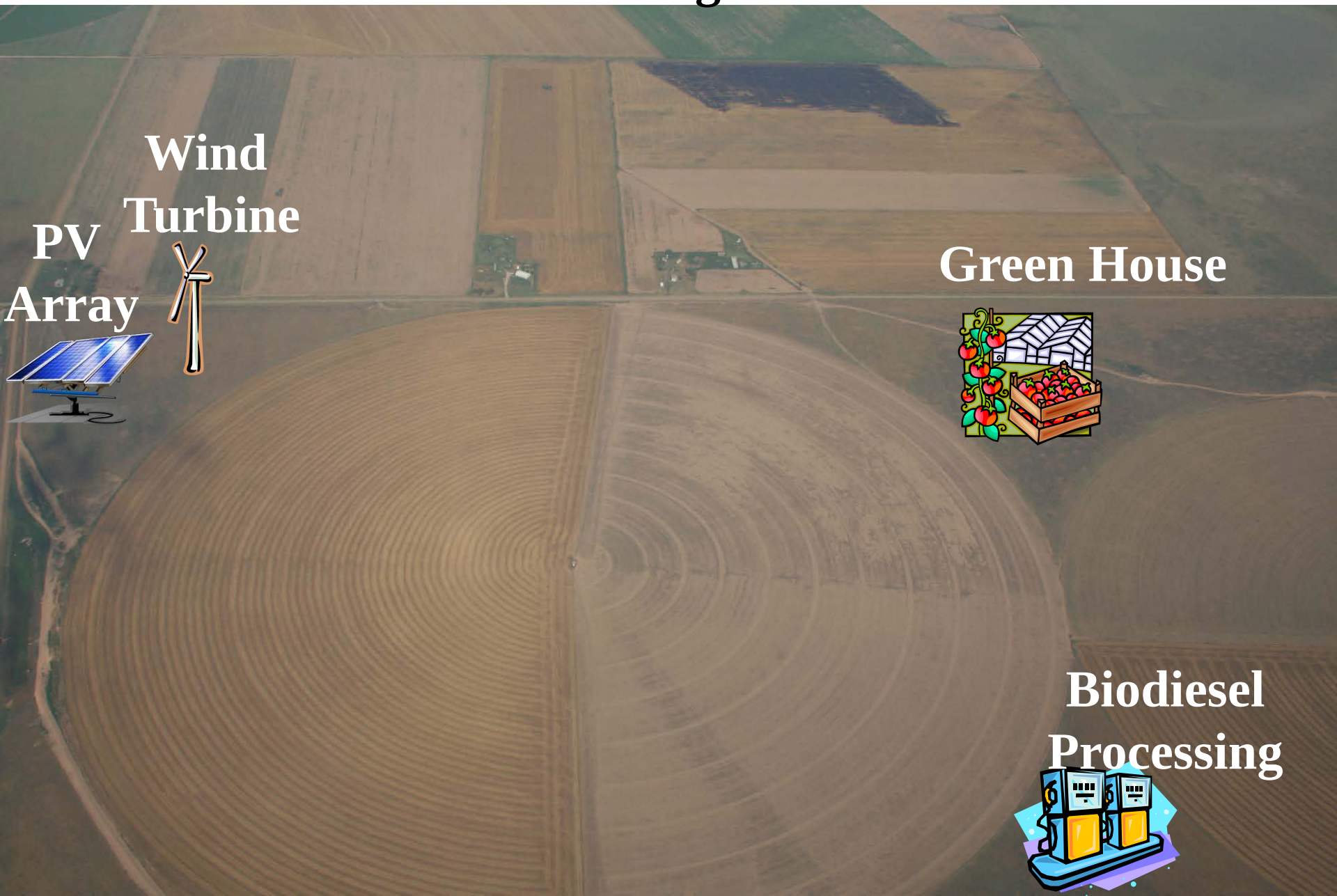


Note: PVWind1=120 kW PV with 50 kW WT (25m)
PVWind2=90 kW PV 1-axis Trk with 50 kW WT (2

Conclusions

- To improve match of irrigation requirement to wind/solar resource, need to combine winter crop (like winter wheat) with a summer crop (like corn).
- Best two locations for using wind/solar hybrid for irrigating crops are Texas Northern High Plains and Southwestern Kansas.
- Solar-PV is best match to crop irrigation water needed in the Texas Northern High Plains, though wind/solar hybrid may be more cost effective.
- PV efficiency assumed to be 14%, but if efficiency could be improved to 40% (like well designed wind turbine), PV array could be ~ 1/3rd the size.

Hybrid Solar PV & Wind Turbine Powered Irrigation for Texas High Plains?



USDA Ag Census (Irrigated Acres)

State	1997	2007	New Ranking
California	8,712,893	8,016,159	# 2
Nebraska	6,939,036	8,558,559	# 1
Texas	5,484,663	5,010,416	# 3
Arkansas	3,717,217	4,460,682	# 4
Idaho	3,493,542	3,299,889	# 5
Colorado	3,430,129	2,867,957	# 6
Kansas	2,707,489	2,762,748	# 7
Montana	1,994,484	2,013,167	# 8
Oregon	1,948,739	1,845,194	# 9
Washington	1,705,025	1,735,917	# 10
Total U.S.	55,058,128	56,599,305	

USDA est. Irrigation Water Use (ac-ft)

State	1998	2008	New Ranking
California	25,153,495	22,599,659	#1
Texas	7,473,880	6,819,783	#3
Idaho	6,030,447	6,228,403	#5
Arkansas	5,516,603	8,631,781	#2
Colorado	5,052,612	4,541,276	#7
Nebraska	4,975,330	6,699,545	#4
Arizona	4,117,652	4,622,309	#6
Kansas	3,589,226	3,146,607	#10
Washington	3,364,585	3,781,371	#8
Oregon	3,255,501	3,276,679	#9
Total U.S.	90,563,665	91,235,036	