SUSTAINABLE ENERGY SOLUTIONS

Operational Excellence in Wind Energy Logistics and Supply Chains

Dr. Bayram Yildirim and Ranjith Krishnamurthy

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Problem Description

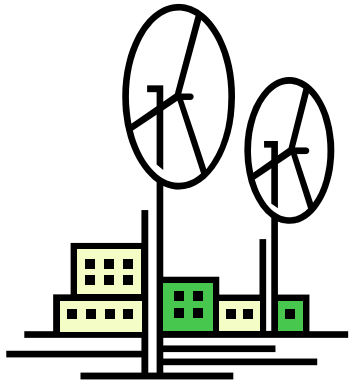
In this research project, our goal is to investigate the larger sized wind turbine supply chains and determine the challenges at installation, operation, maintenance and end of life of a wind energy project. For Vestas, the logistics operations required at the installation of a project of a wind turbine was up to 25% of the cost of the whole project in 2006.

Major Supply Chain and Logistics Problems

- Project management in the construction of the wind mill
- Supplier selection in wind turbine supply chains
- Logistics and transportation of very large items
- Crane Scheduling Problems
- Capacity planning
- Forecasting the demand and supply of electricity
- Inventory and maintenance planning
- Revenue Management for wind farm contractors
- Disassembly of the wind mill at the end of economical service.

Importance and Expected Results

Careful considerations should be given to short, medium and long term planning activities in the wind energy supply chains. This research will result in addressing some of the challenges in system integration and planning.



Key Component Production Capacity

Component	North America	Europe	Asia/Pacific
Blades	20%[1]	50%	30%
Gearbox	7%	75%	18%
Generator	-	70%	30%
Bearings	15%	70%	15%
Castings	7.5%	62.5%	30%

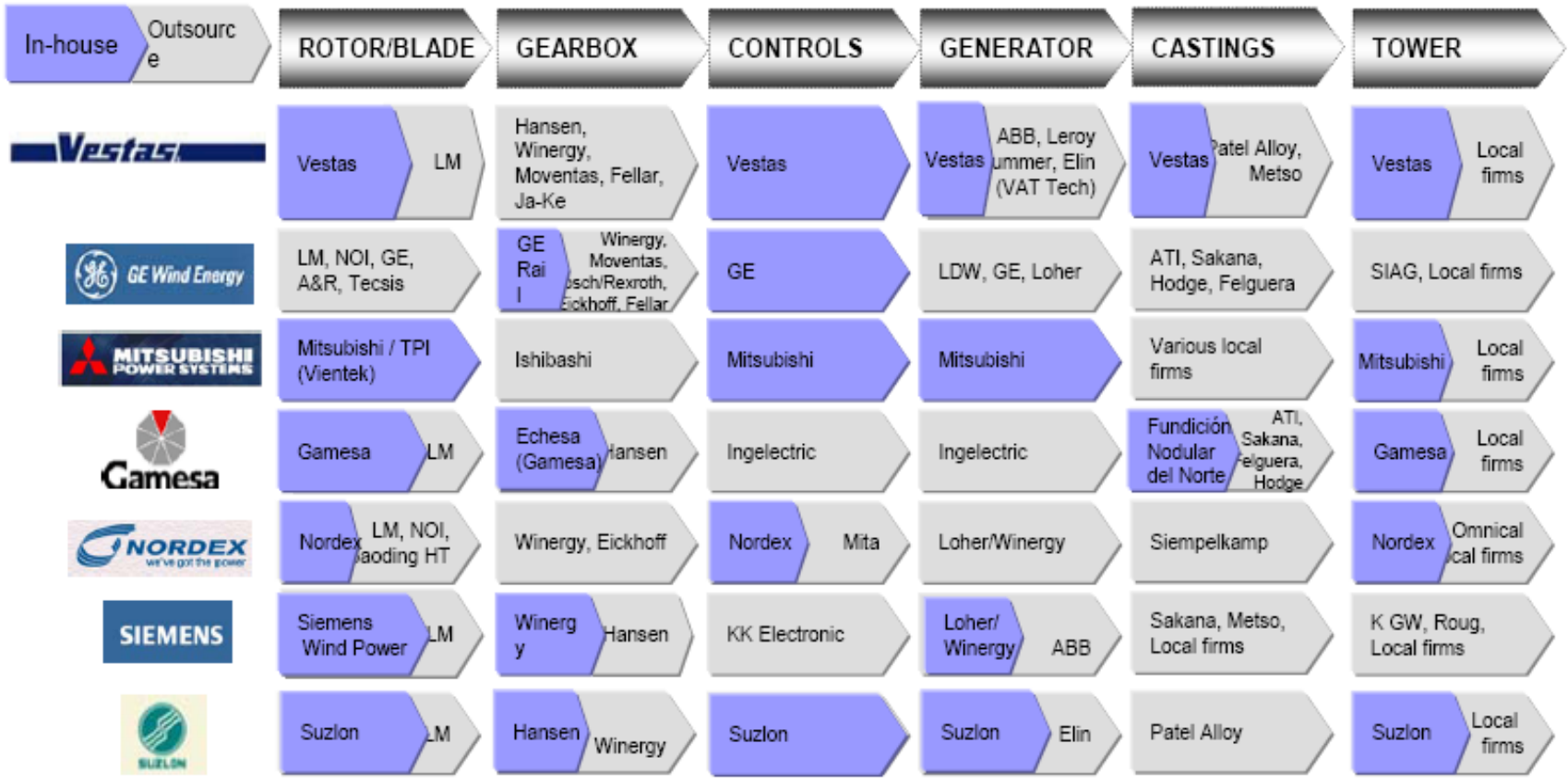
2012 Capacity Forecast

North America	Europe	Asia-Pacific
Total: 75.9 MW (27%)	Total: 130 MW (46%)	Total: 67.6 MW (27%)
Incr: 14.6 MW (31%)	Incr: 18.8 MW (40%)	Incr: 13.8 MW (29%)

Note 1: Includes South America & does not include recent capacity expansions in the US
Source: BTM Consulting, MAKE Consulting

US Wind Turbine Supply Chain

Vertical Integration in the Wind Turbine Supply Chain



Note: Value chain positions are approximate.

Source: Suppliers, Emerging Energy Research

Various global turbine vendors have adopted unique vertical integration strategies, with several major OEMs bringing component supply in-house

Bottlenecks

Current Bottlenecks

–Industrial Gearboxes Availability

–Large Bearings Availability

–Generators/ Generator Components Availability

Anticipated Bottlenecks

–Capacity problems in manufacturing of towers, gearboxes, bearings, generators and blades

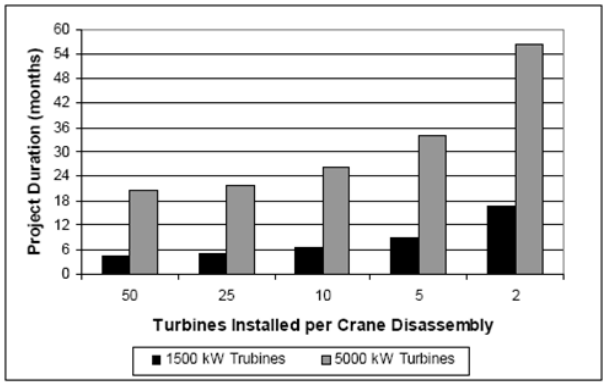
–Domestic Transportation Capacity for large items

–Availability of Trained Wind Energy Professionals

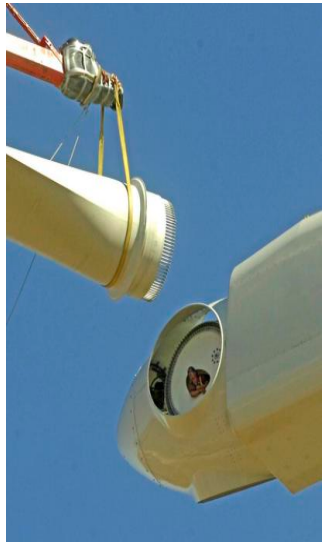
–Crane Availability for installation and maintenance of wind mills

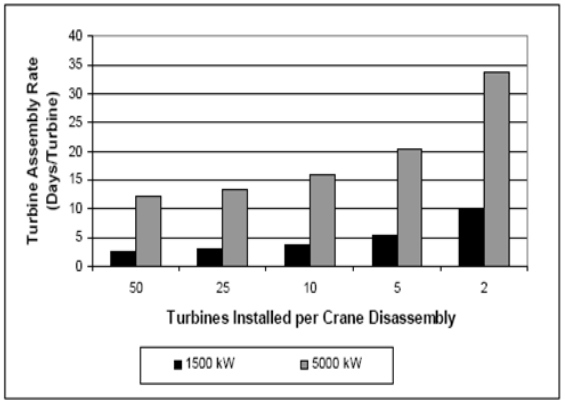
Crane Scheduling Problem

Very large cranes (350-600 tons) are needed to install large wind turbines (>3000 kW). Availability of these cranes are scarce. Careful planning and optimal scheduling of these cranes may reduce the project duration and decrease the payback period significantly



Influence of terrain impacts on project duration

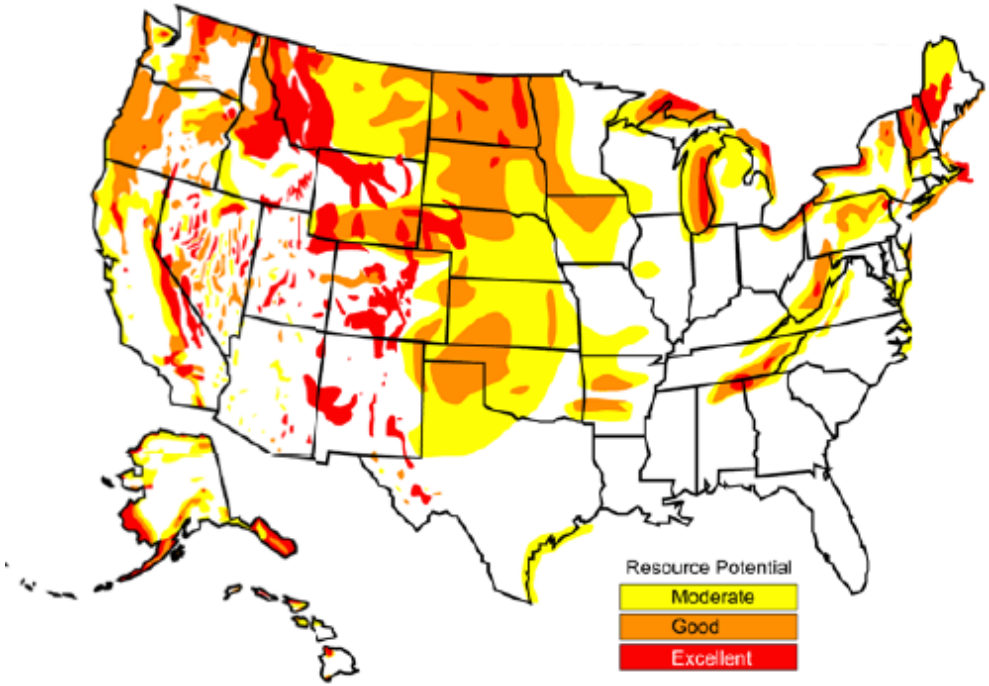


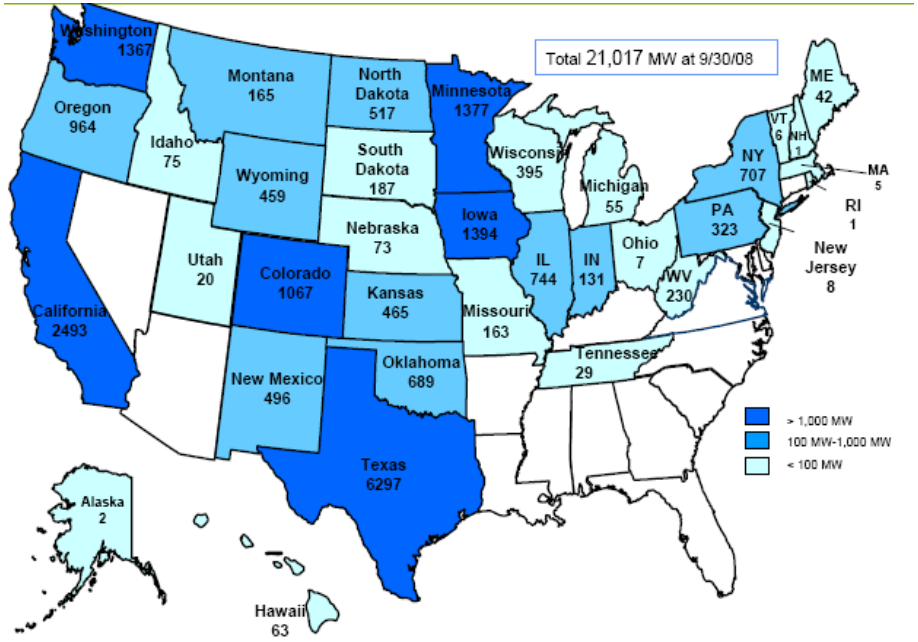


Influence of terrain impact to turbine assembly rates

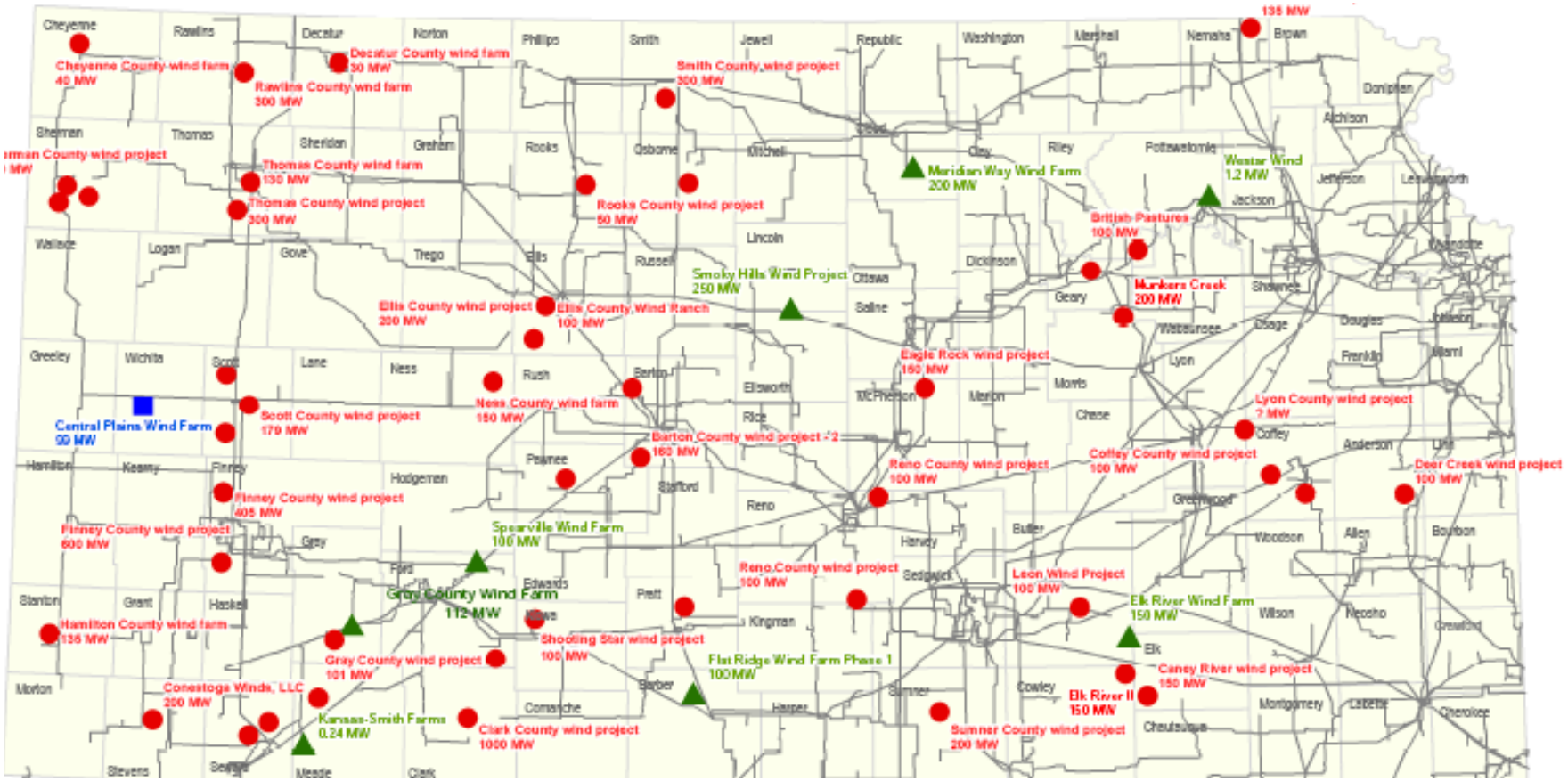
THE TOP TWENTY STATES for wind energy potential, as measured by annual energy potential in the billions of kWhs, factoring in environmental and land use exclusions for wind class of 3 and higher.

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





PROPOSED and EXISTING WIND PROJECTS in KANSAS

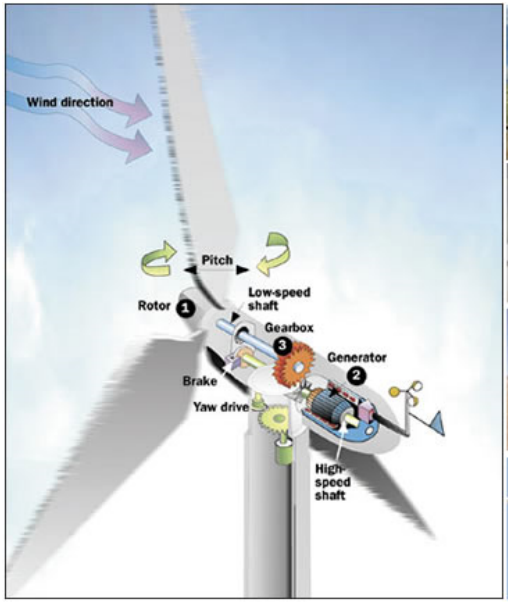


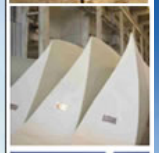
- Manufacturing Key Components in Kansas
  - Expertise in blades and composites
- Workforce Development
  - Manufacturing
  - Construction
  - Operation and Maintenance
- Incentives by the State

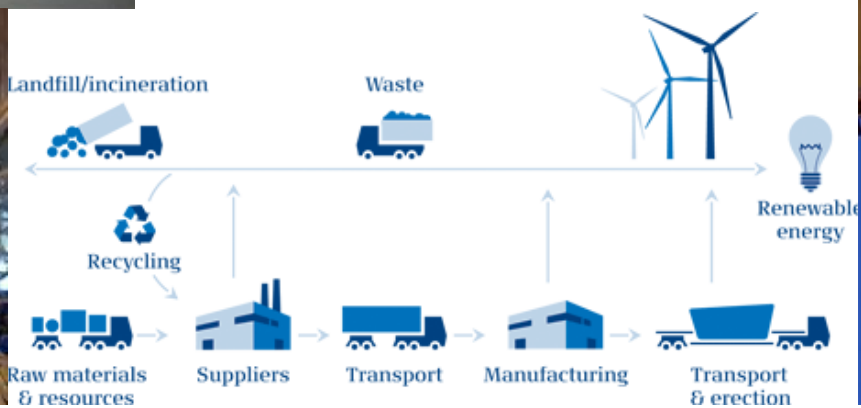
There is a need for an entity which introduces manufacturers in Kansas to the opportunities in the wind supply chain (e.g., Great Lakes Wind Network)

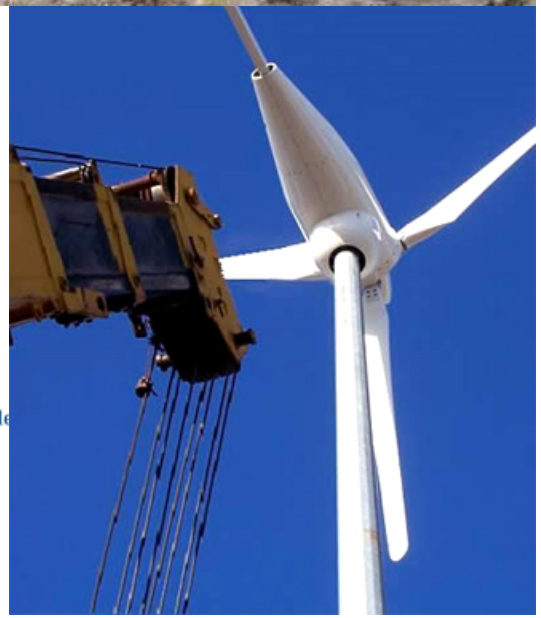
- help create new business opportunities
- link buyers with sellers
- provide assessment and coaching services to manufacturers
- educate on market needs and trends
- Provide manufacturers with a voice for sound public policy

(Department of Commerce)


Wind direction
Pitch
Low-speed shaft
Rotor
Gearbox
Generator
Brake
Yaw drive
High-speed shaft




Landfill/incineration
Waste
Renewable energy
Recycling
Raw materials & resources
Suppliers
Transport
Manufacturing
Transport & erection



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