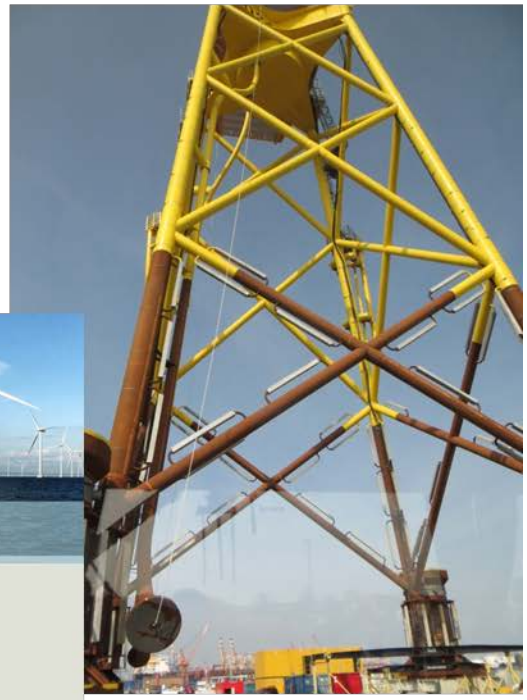
U.S. Department of Energy Project: "U.S. Wind Energy Manufacturing and Supply Chain: A Competitiveness Analysis"



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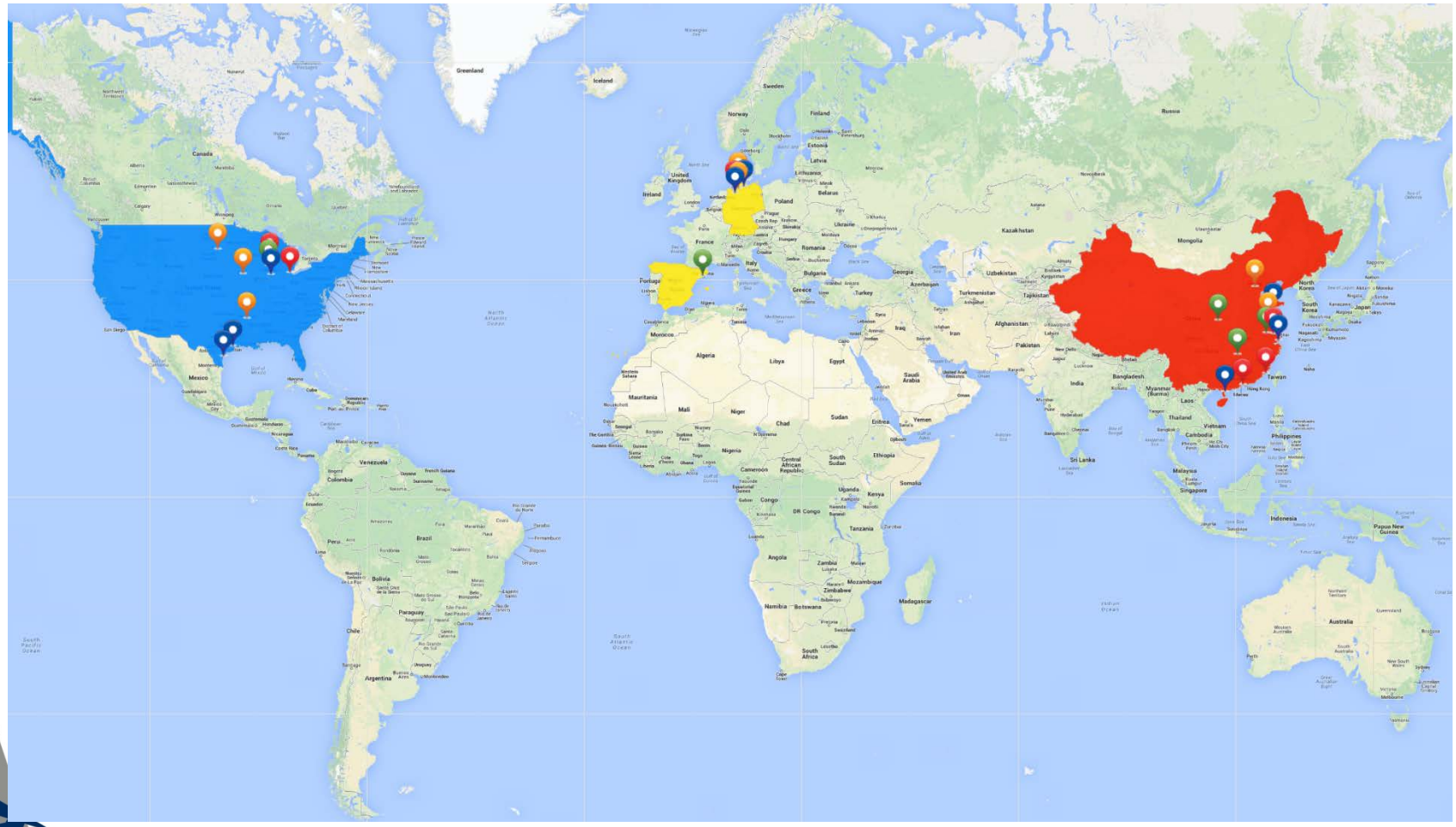
Manufacturing Competitiveness: US vs. Europe vs. Asia – 22 Manufacturers Total



Limited Snap Shot Study - 2013

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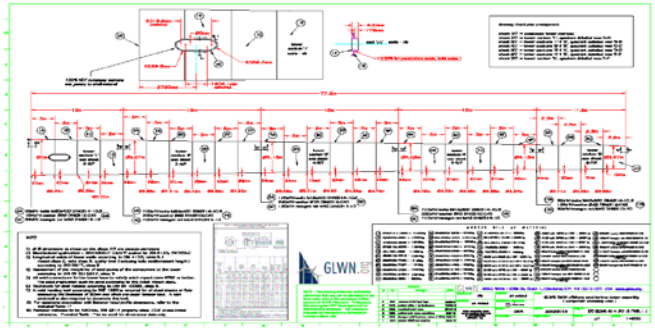
Key Components

Unique GLWN process

- **Standardized component specifications & drawings**



- **Onsite reviews: Validated cost and process data from 22 manufacturers**

- **Analytics: Cost Breakdown Analysis, Value Stream Mapping**

Item Description	Unit of Measure	Raw Material Detail	Total Weight	Quantity	Unit Cost	Material Total	Supplier Name	Country of Mfg	Handling
Steel Plate 27 mm (1A, 1B, 1C, 1D)	mt	A709 Gr50	39.6	4	960.00	38016.00	Nucor	USA	0.00
Steel Plate 26 mm (2A, 2B, 2C)	mt	A709 Gr 50	35.3	3	960.00	33888.00	Nucor	USA	0.00
Steel Plate 25 mm (2D, 2E, 2F)	mt	A709 Gr 50	34.7	4	960.00	33312.00	Nucor	USA	0.00
Steel Plate 24 mm (3A, 3B, 3C)	mt	A709 Gr 50	29.5	3	960.00	28320.00	Nucor	USA	0.00
Steel Plate 23 mm (3D, 3E, 3F)	mt	A709 Gr 50	28.2	4	960.00	27072.00	Nucor	USA	0.00
Steel Plate 22 mm (4A, 4B, 4C)	mt	A709 Gr 50	24.3	3	960.00	23328.00	Nucor	USA	0.00
Steel Plate 21 mm (4D, 4E, 4F)	mt	A709 Gr 50	23	4	960.00	22080.00	Nucor	USA	0.00
Steel Plate 20 mm (5A, 5B)	mt	A709 Gr 50	19.3	3	960.00	18528.00	Nucor	USA	0.00
Steel Plate 19 mm (5C, 5D)	mt	A709 Gr 50	11.7	3	960.00	11232.00	Nucor	USA	0.00
Steel Plate 80 mm Door Frame (1E)	mt	A572 Gr50	1.57	1	3942.00	3942.00	Millerbernd	USA	0.00
Manufactured Flange A-A (Sheet 2 of 7) (1F)	mt	S355NL-Z25	7.23	1	1400.00	10122.00	TBD	Asia	5615.00
Manufactured Flanges B-B (Sheet 3 of 7) (1G, 2G)	mt	S355NL-Z25	14.18	2	1400.00	19852.00	TBD	Asia	11230.00
Manufactured Flanges C-C (Sheet 4 of 7) (2H, 3G)	mt	S355NL-Z25	7.739	2	1400.00	10834.60	TBD	Asia	11230.00
Manufactured Flanges D-D (Sheet 5 of 7) (3H, 4G)	mt	S355NL-Z25	6.78	2	1400.00	9492.00	TBD	Asia	11230.00
Manufactured Flanges E-E (Sheet 6 of 7) (4H, 5E)	mt	S355NL-Z25	6.43	2	1400.00	9002.00	TBD	Asia	11230.00
Manufactured Flange F-F (Sheet 7 of 7) (5F)	mt	S355NL-Z25	4.46	1	1400.00	6244.00	TBD	Asia	5615.00
HV bolts M80x400 (6A)	piece	HDG		92	92.07	8470.44	TBD	USA	225.00
HV Washer 80 Dia (6B)	piece	HDG		184	8.18	1505.12	TBD	USA	225.00
HV Hexagon Nut M80 (6C)	piece	HDG		92	18.73	1723.16	TBD	USA	225.00
HV Bolts M64x400 (7A)	piece	HDG		100	75.01	7501.00	Dokka	USA	24.50
HV Washer 66 Dia (7B)	piece	HDG		200	7.25	1450.00	Dokka	USA	24.50
HV Hexagon Nut M64 (7C)	piece	HDG		100	14.63	1463.00	Dokka	USA	24.50
HV Bolt M56x300 (8A)	piece	HDG		120	55.21	6625.20	Dokka	USA	24.50
HV Washer 58 Dia. (8B)	piece	HDG		240	6.27	1504.80	Dokka	USA	24.50
HV Hexagon Nut M56 (8C)	piece	HDG		120	26.19	3142.80	Dokka	USA	24.50
HV Bolts M42x300 (9A, 10A)	piece	HDG		200	35.35	7070.00	Dokka	USA	24.50
HV Washer 43 Dia (9B, 10B)	piece	HDG		400	1.25	500.00	Dokka	USA	24.50
HV Hexagon Nut M42 (9C, 10C)	piece	HDG		200	14.89	2978.00	Dokka	USA	24.50
Weld wire	kg		188	1	54.96	8641.00	Lincoln	USA	0.00
Epoxy Zinc Carboline 656 Coating - (equivalent utilized)	kg	Resin for	30.5	1	9.60	292.80	International	USA	0.00
Epoxy HB Carboline 890 Coating - (equivalent utilized)	liter	Hardener		985	13.75	13543.75	International	USA	0.00
Polyurethane Carboline 134 Coating - (equivalent utilized)	liter			1046	11.25	11768.50	International	USA	0.00
				Purchased Totals		387257.17			57045.50

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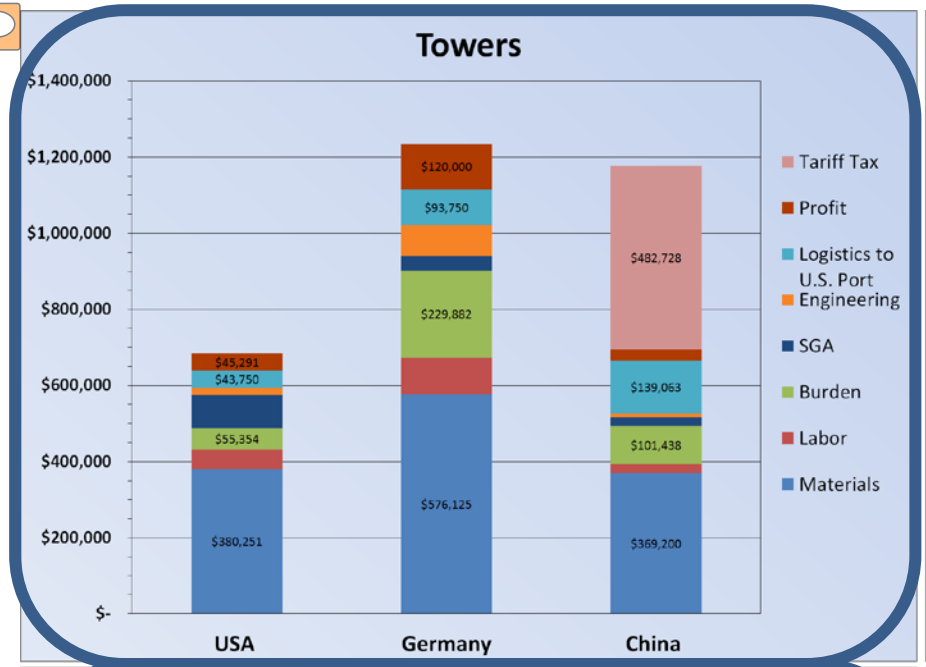

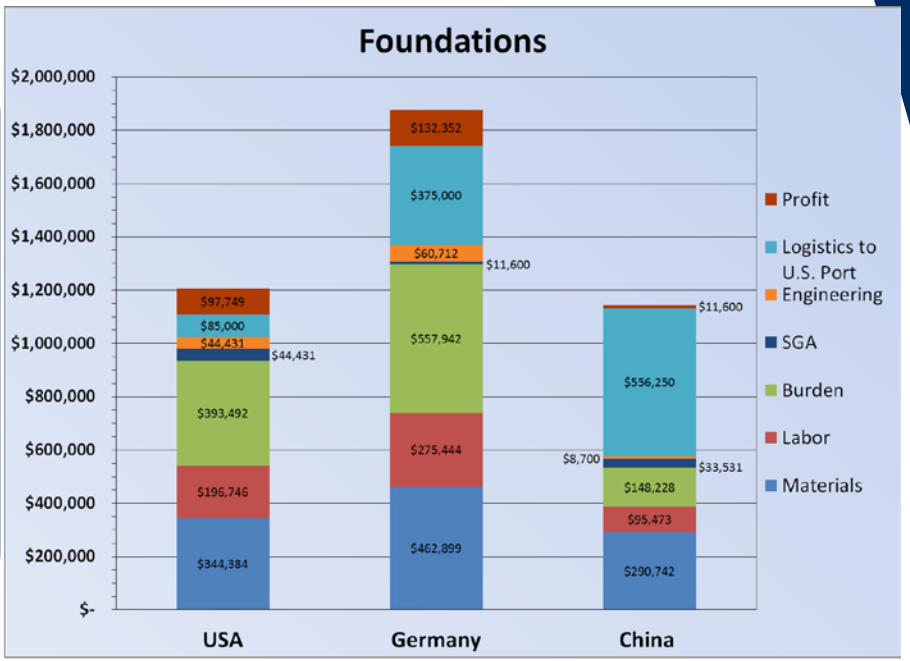

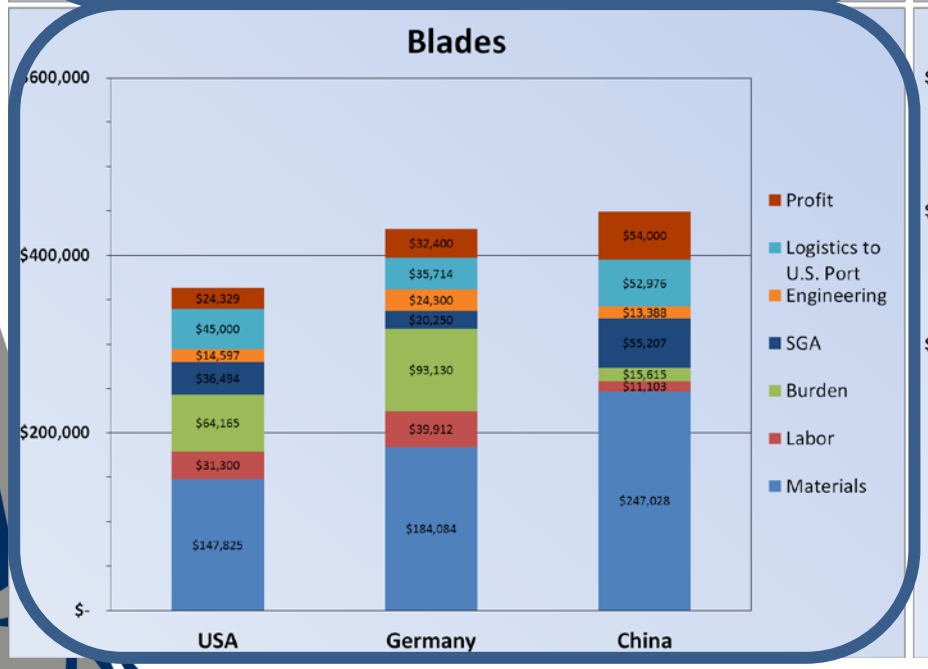

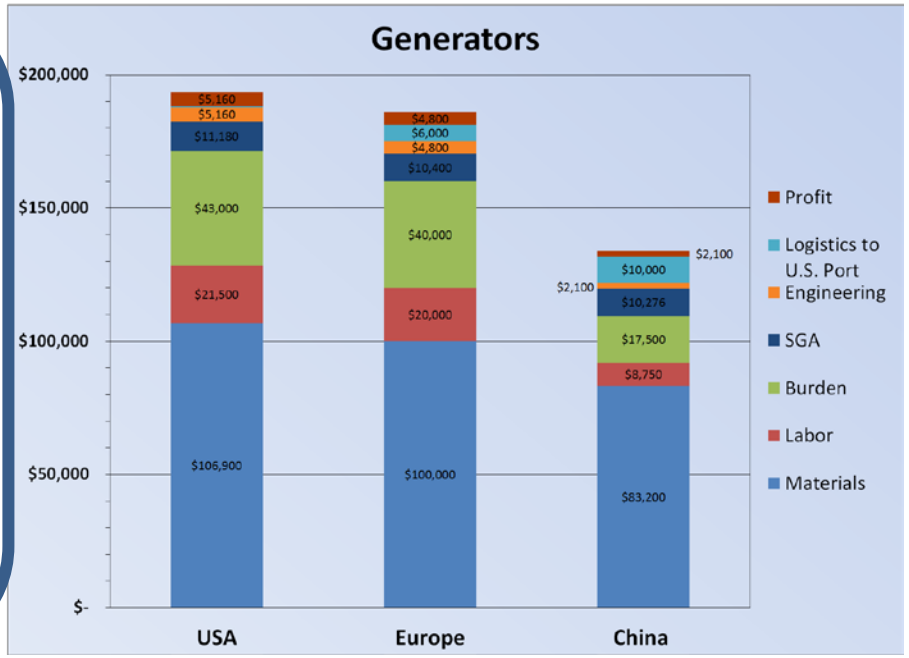

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Cost Breakdown Bar Charts

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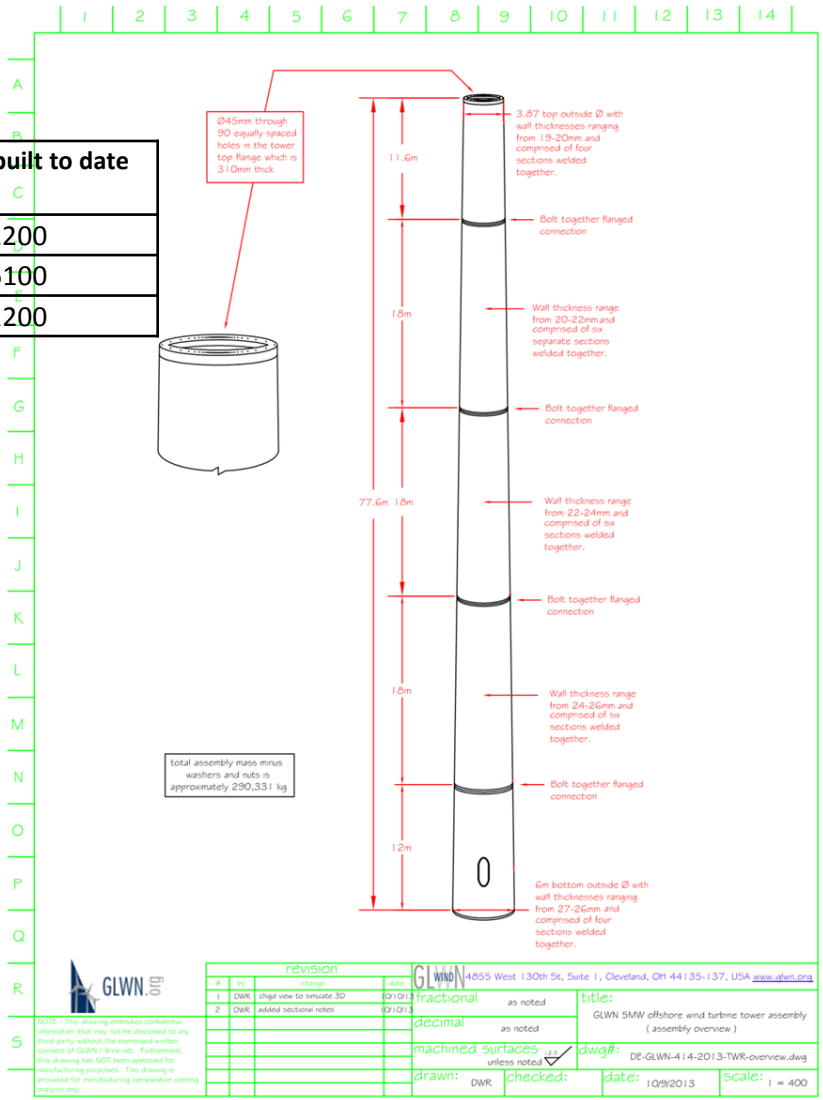
NREL & GLWN 5MW Tower Schematic

	Annual Tower Sales 2012 (Combined)	Annual Tower Capacity as of 2013 (Combined)	Towers built to date
USA (2)	$200M	600	2200
China (2)	$320M	1000	6100
Germany (1)	$90M	250	1200



7 Detailed Drawings

3.87m Diameter Top

6m Diameter Base

77.6m Height

19 to 27mm wall thickness

290,331kg mass

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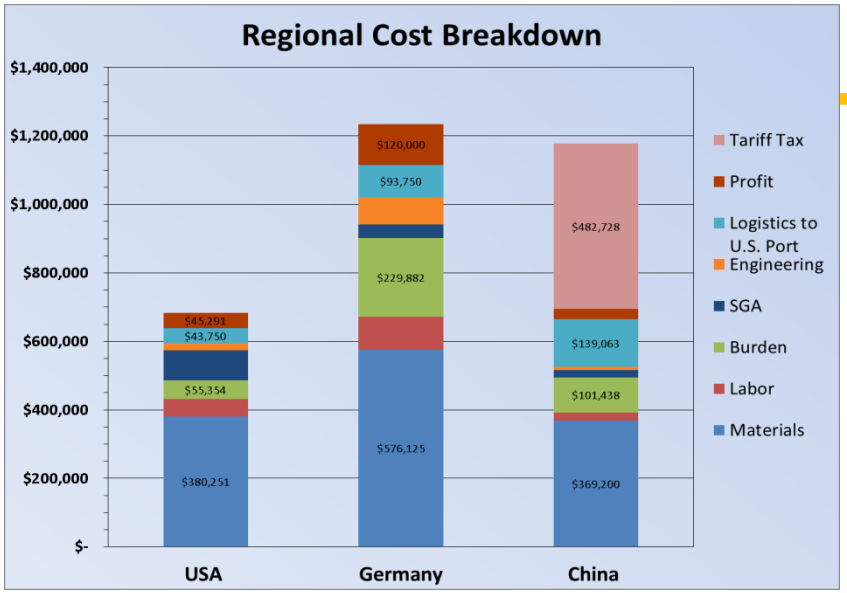
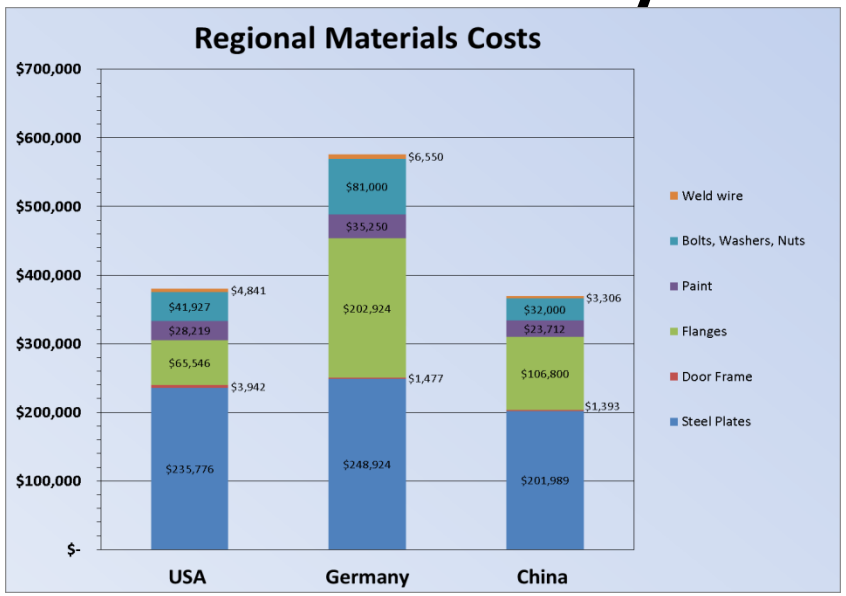
Towers Cost Breakdown Analysis

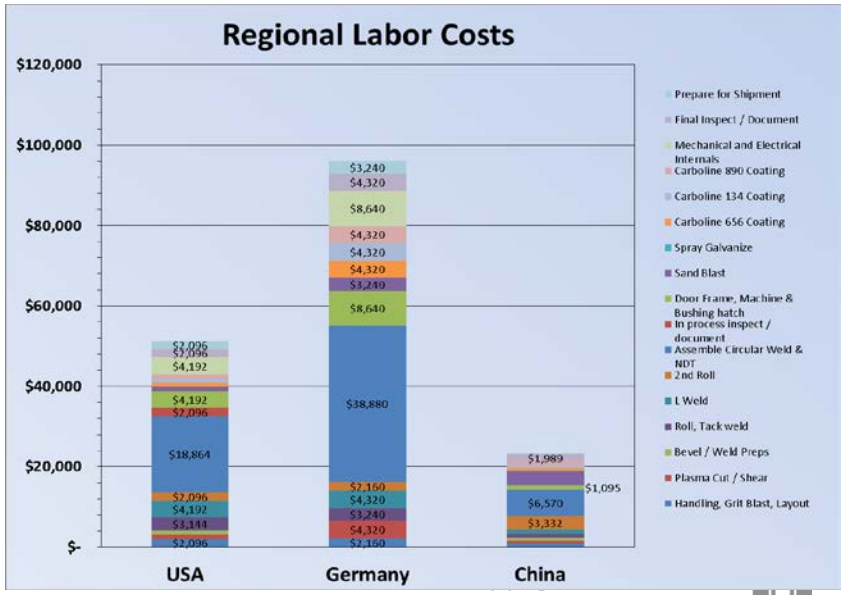




Towers are on avg. 27% of Wind Turbine Cost

R&D Projects from findings (partial list):

- **Material** is over 50% of the cost of the Tower of which Steel Plate accounts for 62% in the U.S. Mfg's to work with steel mills to **optimize material and size of plate** to reduce mill cost and mfg process weld time. **Welding in flat state** is more efficient. Circular weld highest labor hours
- **Weld wire size and delivery system** – 1 to 5 wires – magnetic field and weld pattern impact



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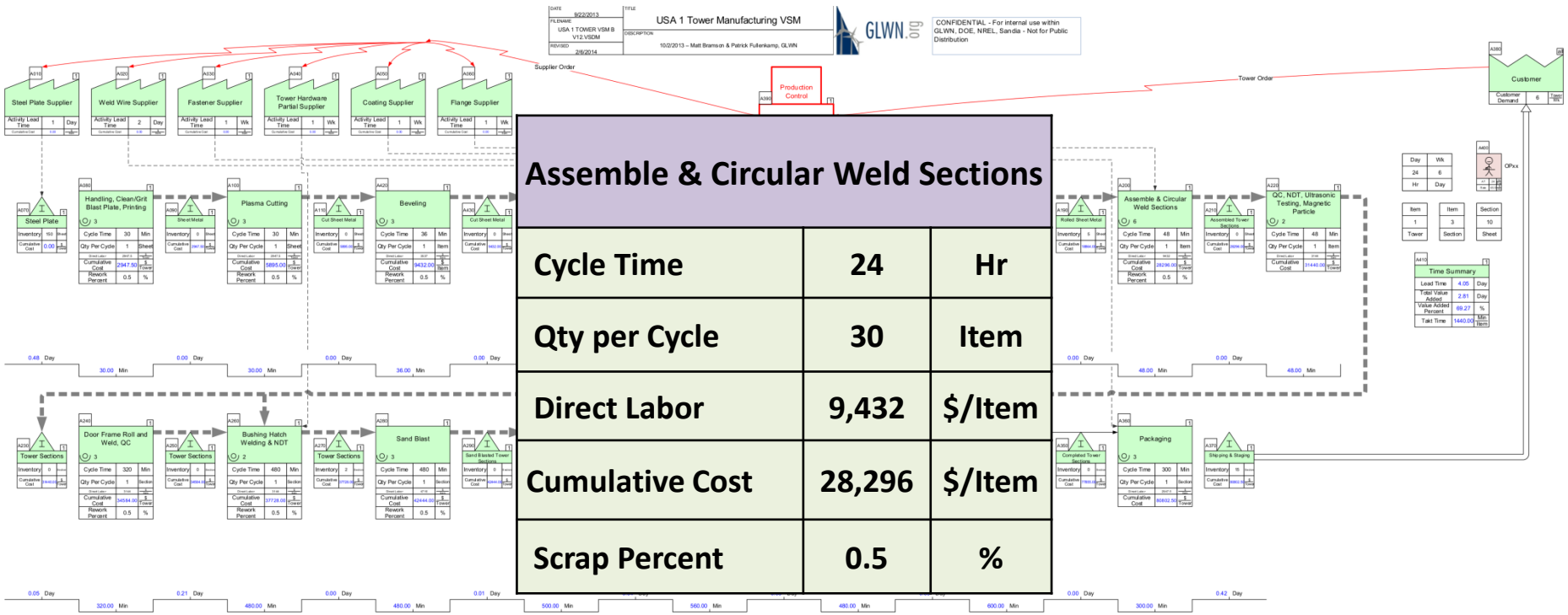
Analysis: **Value Stream Map**

USA 1 Tower – 17 Process Steps



Assemble & Circular Weld Sections		
Cycle Time	24	Hr
Qty per Cycle	30	Item
Direct Labor	9,432	$/Item
Cumulative Cost	28,296	$/Item
Scrap Percent	0.5	%

- Identifies areas of waste and improvement opportunities for domestic suppliers
- Better characterize flow of materials, labor, tasks, and information

Preliminary Data

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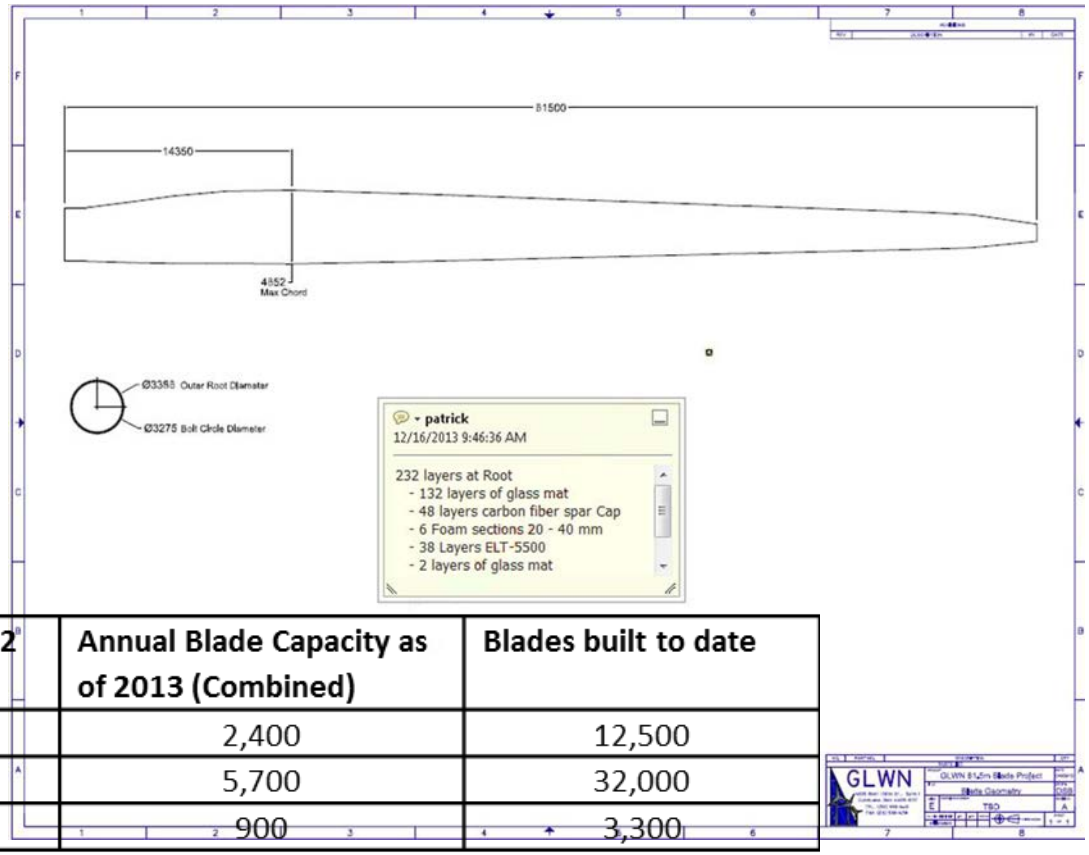
NREL &Sandia 5MW Blade Design
61.5m length – 3.3m Root Dia.- 21,132 kg

12 Drawings (Derek Berry)– Laminate LESW, Laminate LP, Laminate TESW, Root HP, Root LP,SC HP, SC LP, TE HP, TE LP, Geometry, BOM Weights



	Annual Blade Sales 2012 (Combined)	Annual Blade Capacity as of 2013 (Combined)	Blades built to date
USA (3)	$2,030M	2,400	12,500
China (2)	$5,100M	5,700	32,000
Germany (2)	$720M	900	3,300

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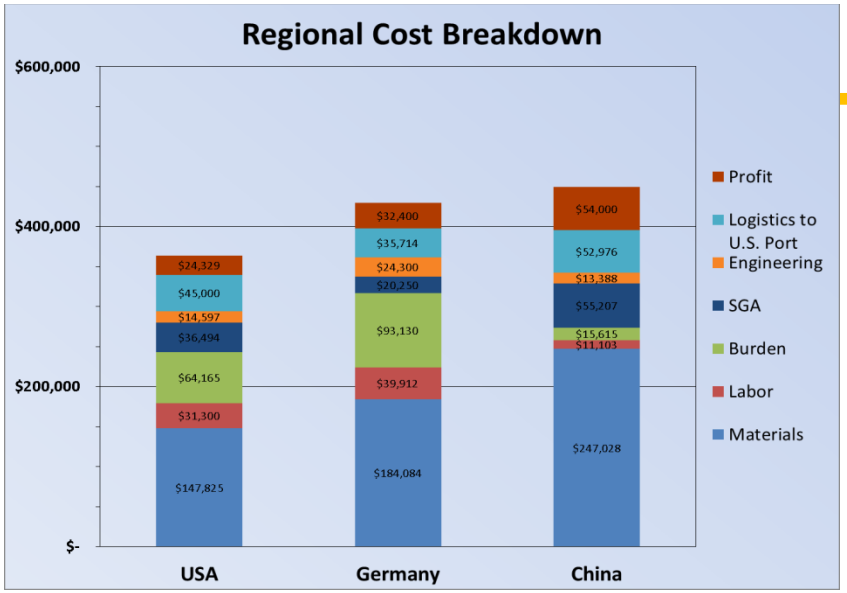
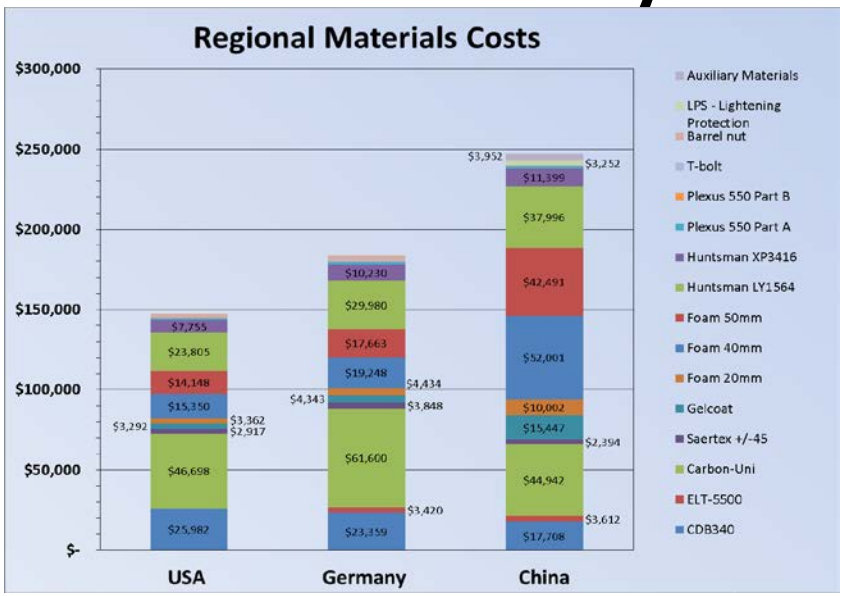
Blade Cost Breakdown Analysis

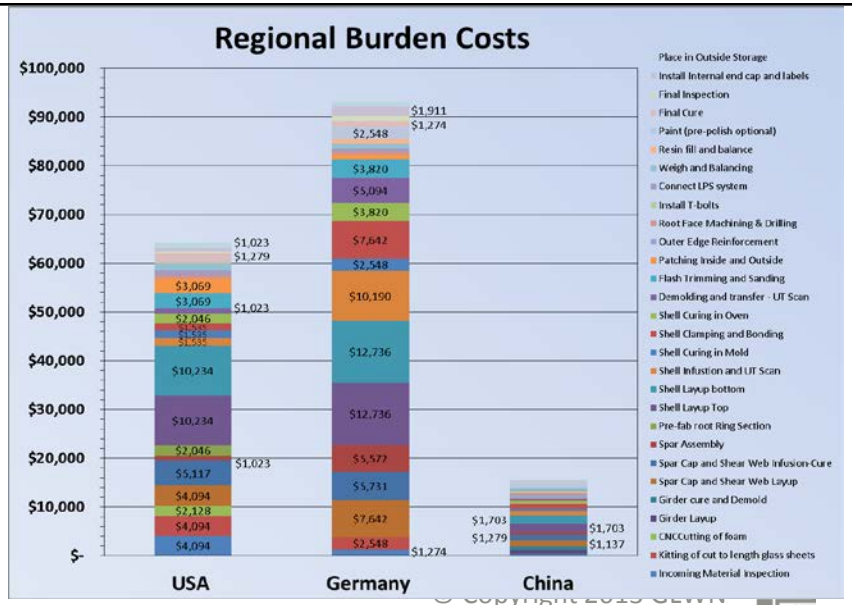




Blades are on avg. 20% of the Wind Turbine Cost

R&D Projects from findings (partial list):

- **Material is ~45%** of the cost of the Blade of which **Resin, Carbon, Glass, & Foam** account for 90% of the U.S. material cost. Material Improvements that provide material cost and process time reductions would be of most benefit
- **Blade design and analysis** looking at: power output, least material usage, shape with 1 or 2 piece for cost and transportability
- **Smart Automation**



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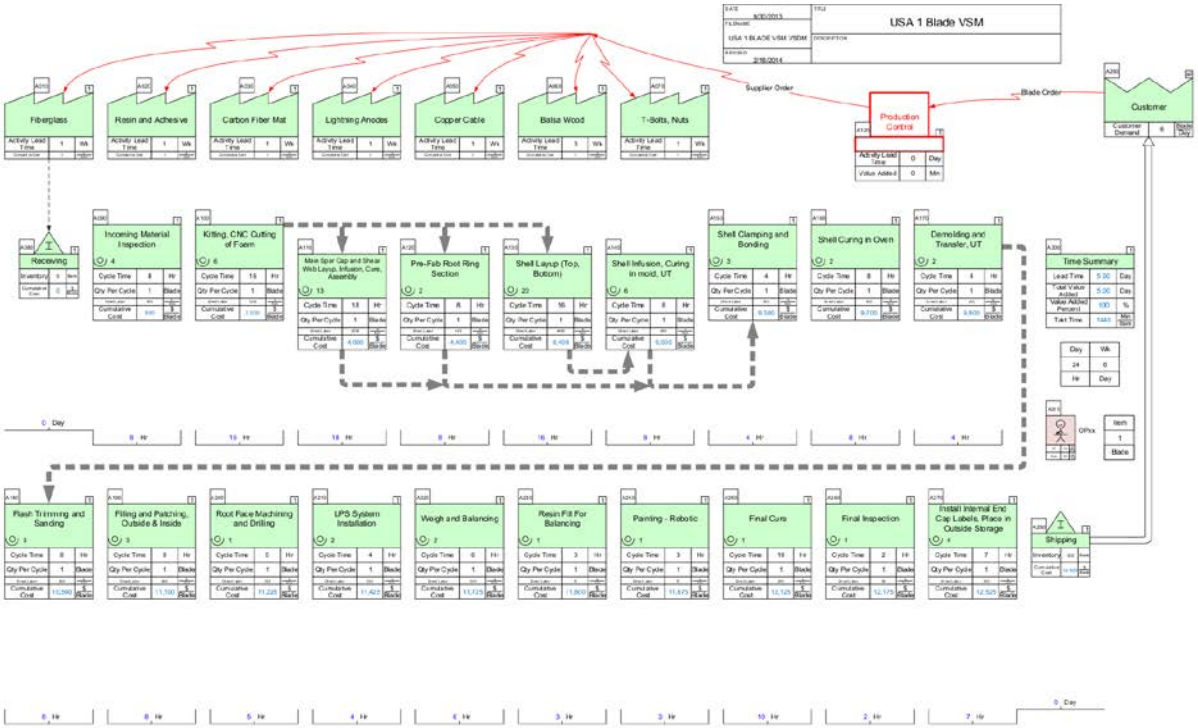
Analysis: **Value Stream Map**

USA 1 Blade – 19 Process Steps



Shell Layup (Top & Bottom)		
Cycle Time	16	Hr
Qty per Cycle	1	Item
Direct Labor	4,000	$/Item
Cumulative Cost	8,400	$/Item

- Identifies areas of waste and improvement opportunities for domestic suppliers
- Better characterize flow of materials, labor, tasks, and information

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Global Competitiveness Scoring,

based on limited snap shot data in 2013

Process Technology		Overall Competitiveness	
	3		3
	1		1
	0		0
US: Towers, Blades, Generators		China: Towers, Generators, Foundations	
Germany: Foundations		US: Blades	

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41 -U.S. Manufacturers: Towers, Blades, Foundations, PM Generators

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U.S. WIND INDUSTRY SUPPLY CHAIN SCORECARD

Land-based and Offshore Turbine Components

Offshore Balance-of-Plant Components

	LAND-BASED - Turbine Components									
	Towers	Blades	Generators	Gearboxes	Composite Housings	Fabricated Support Base	Forged Rings	Forged Shafts	Cast Hubs	Cast Support Bases
3MW	LOW	LOW	LOW	LOW	LOW	LOW	MODERATE-HIGH	MODERATE-HIGH	HIGH	HIGH
5MW	MODERATE-HIGH	MODERATE- HIGH	LOW-MODERATE	LOW-MODERATE	LOW-MODERATE	LOW-MODERATE	MODERATE-HIGH	MODERATE-HIGH	HIGH	HIGH

	OFFFSHORE - Turbine Components									
	Towers	Blades	Generators	Gearboxes	Composite Housings	Fabricated Support Base	Forged Rings	Forged Shafts	Cast Hubs	Cast Support Bases
3MW	LOW-MODERATE	MODERATE-HIGH	LOW	LOW	LOW-MODERATE	LOW	MODERATE-HIGH	MODERATE-HIGH	HIGH	HIGH
5MW	HIGH	HIGH	LOW-MODERATE	LOW-MODERATE	MODERATE	LOW-MODERATE	MODERATE-HIGH	MODERATE-HIGH	HIGH	HIGH

	OFFSHORE - Key Balance-of-Plant		
	Jacket Foundations	Monopile Foundations	Subsea Cabling
3MW	MODERATE-HIGH	MODERATE-HIGH	HIGH
5MW	MODERATE-HIGH	HIGH	HIGH

Scorecard Legend

LOW	Can manufacturing the component today or a similar product (No real capital investment required)
MODERATE	Requires some capital investment (Minor facilities upgrades and/or operations expenses)
HIGH	Major capital investment required (New location/facility, major technology or equipment upgrades)

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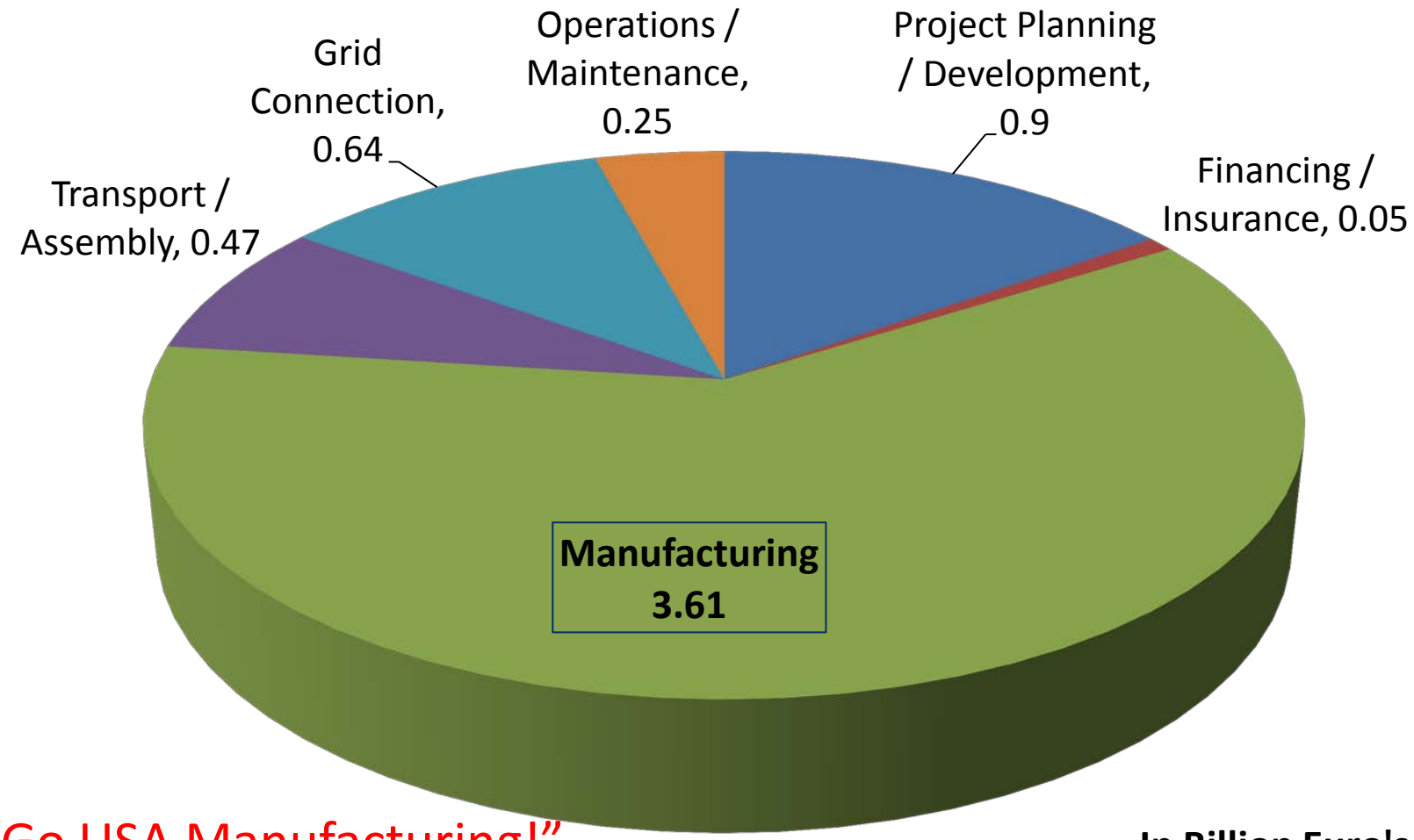
Germany Offshore Wind

Total Value Add - 5.9B as of 2011



"Go USA Manufacturing!"

In Billion Euro's

Source: wab, windenergie agentur

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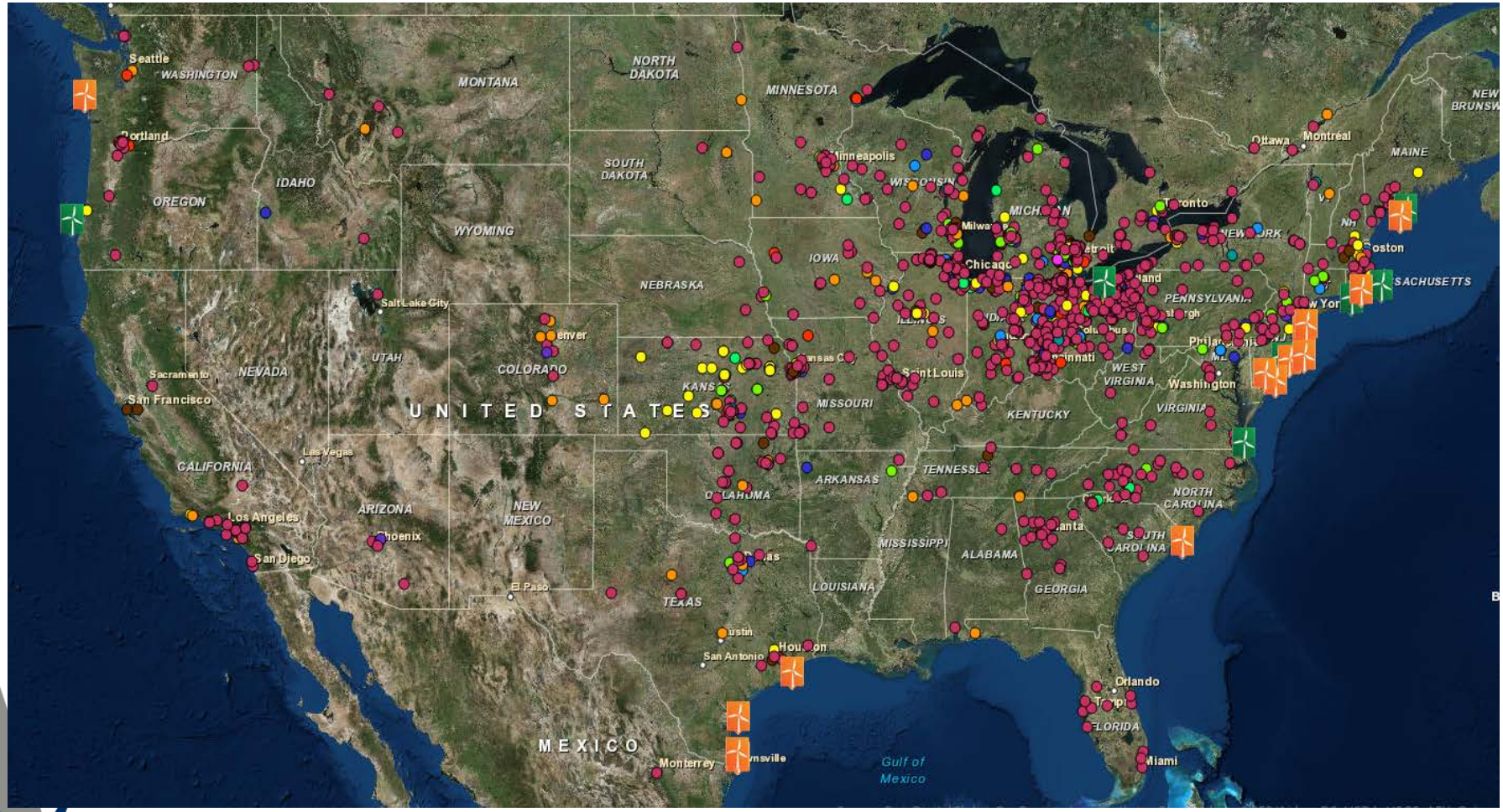
Why is this study important forU.S. Mfgs?



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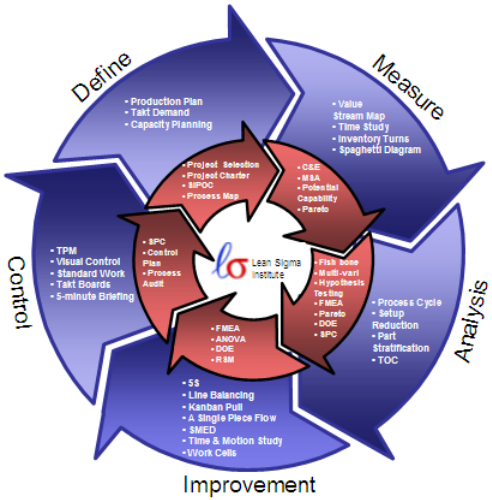
Major Observation



- U.S. has a good foundation – more to improve
- Lessons learned from auto, 30-50% process savings potential observed
- **If you don't make it, you can't innovate it**
- The US has a major market opening up: Offshore Wind. Logistics <u>WILL</u> matter.
- Global competition sees this as theirs
- Winning this business is in the cards for US companies that invest wisely

Full Report at www.glwn.org

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THANK YOU!

Photo: North Sea Germany June 2013 BARD 1

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