AN INDUSTRY PERSPECTIVE ON THE MANUFACTURING OF FUTURE LARGE WIND TURBINE BLADES WITH AN EMPHASIS ON SUSTAINABILITY AND AUTOMATION

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World's first wind turbine blade beyond 100 meters, built by LM Wind Power

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LM Wind Power
A leading blade supplier to the wind industry

13 blade factories

13,233 People worldwide

1/5 turbines in the world have LM Wind Power blades

Global capacity and supply chain

251 million metric tons of CO₂ mitigated

241,000 blades produced since 1978

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Big, Bigger, Biggest

Calculations are based on European data.
A wind turbine blade is a complex structure to design and manufacture

Wind turbine blade materials (typical examples)

- **Reinforcement fibres** (glass, carbon or hybrid)
- **Polymer matrix** (epoxy, vinylester, polyester)
- **Sandwich core** (balsa wood, PET, PVC)
- **Surface coating** (polyester, polyurethan)
- **Metals** (root inserts, down conductor)

Premoulding/gelcoating  Dry lay-up  Resin infusion  Assembly  Demoulding  Postmoulding/finishing

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Blade manufacturing is still a manual and people dependent process.

From wet hand layup to dry layup and VARTM.

- 1978: LM 34.0 P
- 1993: LM 24.0
- 2002: LM 61.5 P
- 2004: LM 73.5 P
- 2012: LM 88.4 P
- 2016: LM 107 P
- 2019: LM 107 P

6-7 m
Outlook

» Blade length?
» Modular wind turbine blades?
» Automation?
Sustainability is about enhancing enterprise value

» Drive operational excellence
» Exceed customer expectations
» Reduce costs
» Improve safety
» Differentiate our brand
» Improve reputation with key stakeholders
» Reduce risk
» Motivate and engage employees

Sustainability is about the planet, but it is also good business
Carbon Neutral Journey…
We chose to lead, Not follow

2010 – LM Wind Power joins UN Global Compact

December 2016: LM Wind Power pledges to become Carbon Neutral by 2018: First for a Wind value chain company

2016-2018: Four main workstreams make up our carbon neutrality program, which we continuously develop and improve

LM Wind Power achieved Carbon Neutral status during 30 August 2018 - Four months ahead of pledged timeline

Visit www.lmwindpower.com/gocarbonneutral for 10 steps to become a carbon neutral business
Carbon neutrality = balance!

Where did our emissions come from in 2017?

- **ELECTRICITY**: 41% Emissions from purchased electricity that powers the lights, computers, tools and other equipment at our plants and offices.
- **DELIVERY OF MATERIALS**: 22% Emissions from transporting materials such as fiberglass or liquid resin polyester from suppliers to our factories.
- **WASTE DISPOSAL**: 14% Emissions from landfiling, incinerating and recycling the waste we produce.
- **STATIONARY EQUIPMENT**: 9% Emissions from stationary equipment such as boilers or back-up electricity generators in our plants.
- **EMPLOYEE COMMUTING**: 8% Emissions from commuting to work, for instance by car or public transport.
- **BUSINESS TRAVEL**: 4% Emissions from business travel, for instance by airplane, public transport or car.
- **COMPANY VEHICLES**: 2% Emissions from company-owned vehicles such as cars, trucks or forklifts.
Connecting carbon neutrality and cost savings

$12 million in waste reduction savings in 2019

Where did our emissions come from in 2019?

- Delivery of Materials: 25% - Emissions from transporting materials such as fiberglass or liquid resin polyester from suppliers to our factories.
- Waste Disposal: 24% - Emissions from landfilling, incinerating and recycling the waste we produce.
- Employee Commuting: 13% - Emissions from commuting to work, for instance by car or public transport.
- Stationary Equipment: 12% - Emissions from stationary equipment such as boilers or back-up electricity generators in our plants.
- Electricity: 14% - Emissions from purchased electricity that powers the lights, computers, tools and other equipment at our plants and offices.
- Business Travel: 4% - Emissions from business travel, for instance by airplane, public transport or car.
- Company Vehicles: 4% - Emissions from company-owned vehicles such as cars, trucks or forklifts.

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Powering a cleaner world with green blades

Blade Life Cycle

- Virgin Blade: Installation
- End-of-Life Blade: Decommissioning
- Virgin Materials: Manufacturing
- Manufacturing waste: Disposal
- Recycled Materials: Recycling
- Other Industries: Transport

Materials

Recycling
- Prevention
- Recovery
- Disposal
- Waste
- Fragmentation
- Co-processing
- Cement Kiln
- Incineration
- Landfill
- Scultures
- Repurpose
- Recycling
- Recovery
- Disposal
Reducing up- and downstream impacts

- Suppliers
- LM Wind Power’s Operational Control
- Customers

Manufacturing waste: ~20% of materials go to waste

- CO₂: 76%
- CO₂: 11%
- CO₂: 28%
- CO₂: 47%

Virgin materials
Recycled materials

Transport
Materials

Waste
Disposal
Recycling

Landfill
Incineration

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Beyond carbon neutral - Sustainability across the whole value chain

- Sustainability is a mindset
- Lean as a strong foundation
- Waste reduction
- Drive cultural change for a paradigm shift
- Reduction in up- and downstream impacts
Thank you for your time!
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