IOWA STATE UNIVERSITY
Hexcrete Tower Project (DE-EE0006737)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
WIND & WATER POWER TECHNOLOGIES OFFICE

Hexcrete Tower for Harvesting Wind Energy at Taller Hub Heights – Phase II

Iowa State University

SWOT Analysis

Markus Wernli, BergerABAM

Overview

1. SWOT Analysis
   - Purpose of SWOT and Approach
   - Findings
   - Implications on Further Development
   - Implications on Commercialization
2. Technology Readiness Evaluation
3. Conclusions

Strength/Weakness and Opportunity/Threat Analysis

Industry Involvement through Workshop

- Technology Owner and Developer (ISU)
- Tower and Foundation Engineers (BergerABAM, BARR Engineering)
- Concrete Industry (Coreslab, Midstate, Oldcastle, Wells Concrete)
- Erector and Crane Supplier (Bigge)
- Wind Farm EPC (Mortenson)
- Turbine Manufacturer (Siemens)
- Wind Developer (Pattern Energy)
- National Renewable Energy Laboratory

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Purpose of SWOT and Approach

1. Step-by-step Evaluation of Critical Components, Procedures, and Conditions
   - Design and Certification
   - Fabrication
   - Transport
   - Erection
   - Operations & Maintenance
   - Repowering, Recycling
   - Business Case
2. Identification of Hurdles and Opportunities
3. Planning Tool for Implementation Plan

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Findings from SWOT – Tower Fabrication

Strength	Weakness/Threat	Opportunity
• Controlled factory setting • High quality • Simple prismatic formwork • Existing or temporary precast plant • Local fabrication	• Demand for tight tolerances • Large quantity of concrete • Unfamiliarity with UHPC	• Precision formwork • Adjustable formwork • Formwork to be owned by technology provider • Movable on-site precast plant

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Findings from SWOT – Tower Component Transport

Strength	Weakness/Threat	Opportunity
• Flat or prismatic concrete elements to be shipped on standard flatbed trucks • No special transports • Short shipping distance	• Large amount of shipments	• Just-in-time logistics • Smart racks for handling

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Findings from SWOT – Tower Cell Assembly

Strength	Weakness/Threat	Opportunity
• On the ground assembly • Simple components and connections	• Large layout area • Tight assembly tolerances • On critical path, multiple crews	• Just-in-time logistics • Smart rigs for assembly • Fast connections • Preinstalled tower internals

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Findings from SWOT – Cell Stacking and Connection

Strength	Weakness/Threat	Opportunity
• Simple connection - no bolting	• Number of cells • Critical path • Post tensioning during erection	• Fast connections

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Findings from SWOT – Tall Lifts with Crawler Crane

Strength	Weakness/Threat	Opportunity
• Widely used in wind industry • Generally available • Walkable between sites	• Large crane needed for tall lifts • Limited availability of large cranes • Strong soils needed • Partial disassembly before walking • High O&M cost • Not suitable in mountain areas	• Optimization of lift plan • Light weight upper cells • Development of new lifting equipment

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Findings from SWOT – Tall Lifts with Tower Crane

Strength	Weakness/Threat	Opportunity
• No height limit • Crane foundation part of tower foundation • No large crane pad • Lighter cranes	• Crane braced against tower • Disassemble for move • Slow relocation • Typically low lifting capacity	• Lightweight upper cells • Development of new lifting equipment • "Walkable tower crane?"

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Findings from SWOT – Operation and Maintenance

Strength	Weakness/Threat	Opportunity
• High durability • No bolts • No intermediate platforms • Large doorway		• Increase of service life

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Findings from SWOT – Repowering and Deconstruction

Strength	Weakness/Threat	Opportunity
• Long service life • Repowering w/o new towers • Deconstruction = reverse construction • Concrete recycling		• Design for repowering

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Findings from SWOT – Design, Qualification, Certification

Strength	Weakness/Threat	Opportunity
• Advanced level of technology readiness	• Some critical details need improvement • Validation of construction procedures needed	• Design optimization towards construction • Mockup and prototype testing

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Findings from SWOT – Business Case

Strength	Weakness/Threat	Opportunity
• Increase of energy production by reaching higher winds • Low-wind regions • Potential for new markets • Local materials and fabrication • Increased service life	• Expensive and challenging to erect • Niche market	• New wind farm strategies for longer service life • Low-wind regions such as Southeast US

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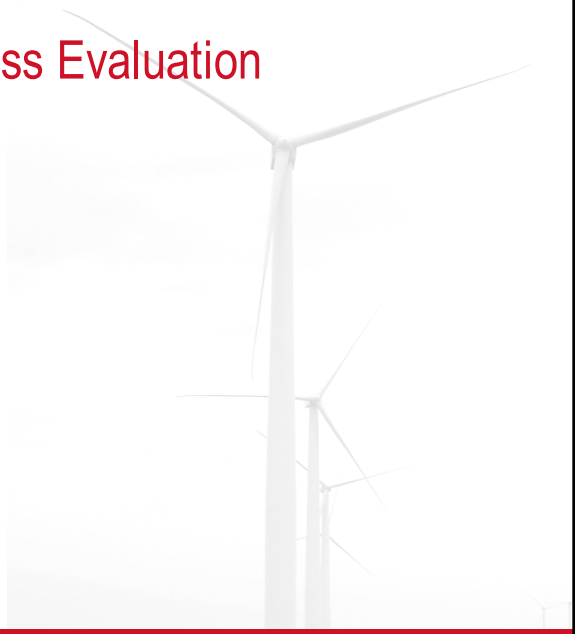
Preliminary Technology Readiness Evaluation



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Definition of Technology Readiness Levels (TRL)

TRL	Description
9 – Standard Industry Practice	Standard industry practice in the U.S.
8 – Infancy Application	Standard industry practice in another part of the word but not in the U.S. or has been used in at least one project in the U.S.
7 – Prototype Testing	A full-scale prototype component has been built and tested in a relevant environment.
6 – Technology Demonstration	The component or procedure has been subjected to full or near full-scale testing in a simulated relevant environment
5 – Technology Development	Standard practice in other industries under similar environment or has been thoroughly analyzed and validated in scaled tests or tests in similar environment.

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Summary of Technology Readiness Evaluation of Hexcrete Tower

New Technology Component or Procedure	TRL
1. Ridged Shape of Tower Cross Section	5
2. Use of Ultra High Performance Concrete	6
3. UHPC Panel to Column Connection Detail	6
4. Detail of Connection between Tower Cells	5
5. Detail of Connection between Tower and Nacelle	8
6. Tower Cell Assembly	8
7. Tower Erection and Turbine Installation Procedure	8
8. Repowering	8

SWOT Conclusions

1. All workshop participants showed high interest
2. Hexcrete at high technical readiness level and with no “fatal flaw”
3. Room for improvement and optimization in particular in constructability
4. Ready for prototype construction and testing

Implications on Implementation Plan

Technology Qualification Plan	Commercialization Plan
• Development of more cost effective joints • PT detailing and procedures for fast installation • Study of cell assembly, lift, and stacking plan • Study of adjustable precision formwork • QC means for construction tolerances • Study of vortex shedding • Design towards certification • Mockup construction and prototype testing • Study of temporary onsite precast plant • Development of on-demand logistics • Development of tower internals • Study of alternative lift equipment • Study of lighter tower top cells • Repower strategies	• Study of likely markets for tall towers • Development of a business plan • Comparison with other tall tower systems • Stakeholder reach out • Study of consortium owned tooling • Familiarization of precast industry with UHPC