Upping the ante with larger DG wind turbines – are we crazy?

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Outline

Brief intro

Developing 5MW wind projects

- Permitting challenges
- Civil design constraints
- Utility interconnection and electrical designs
- Site assessment, production modeling, site suitability reports
- Working with vendors and buyers

Intro

14 years at SUNY Morrisville in upstate NY

- Designed courses on wind, solar, and hydro systems
- Installation, electrical design, project development, and analytics

8 wind turbines from 10 kW to 50 kW

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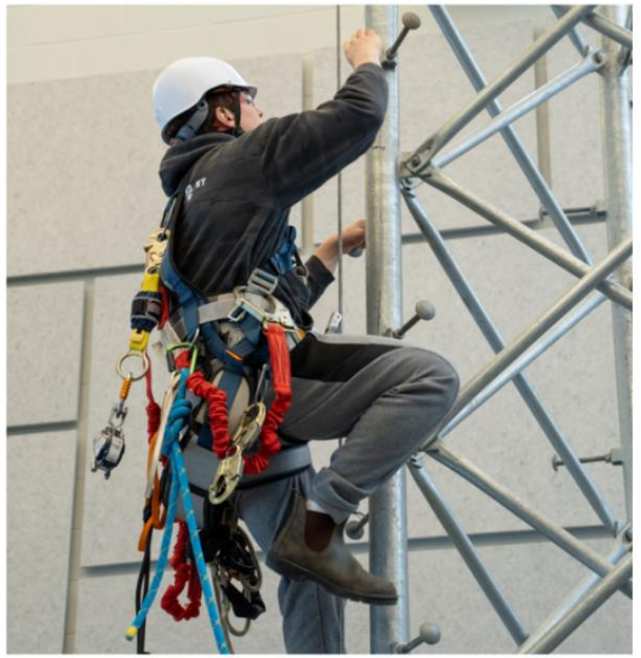

Indoor Tower Lab: 3 towers, each 35’ tall

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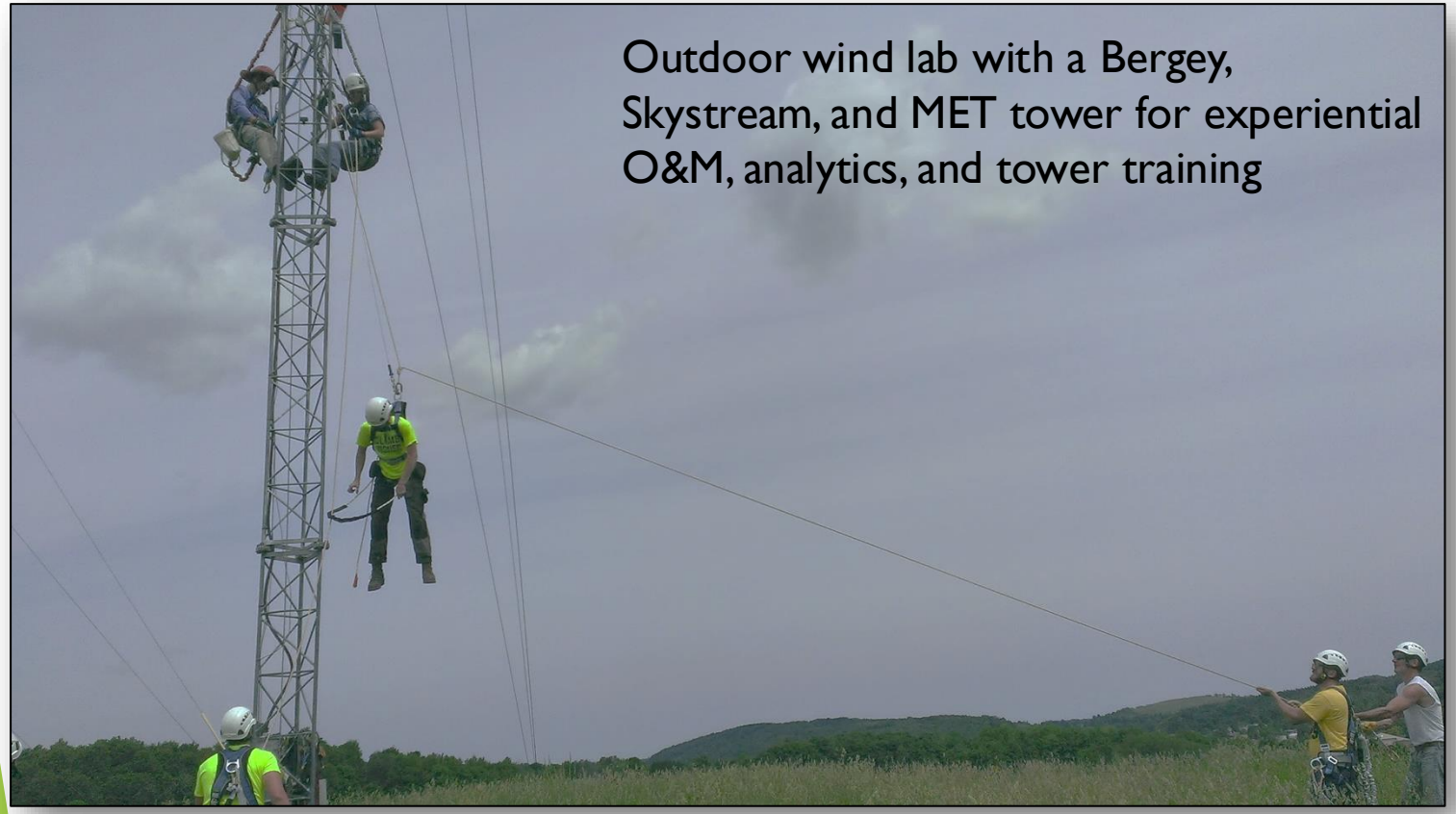
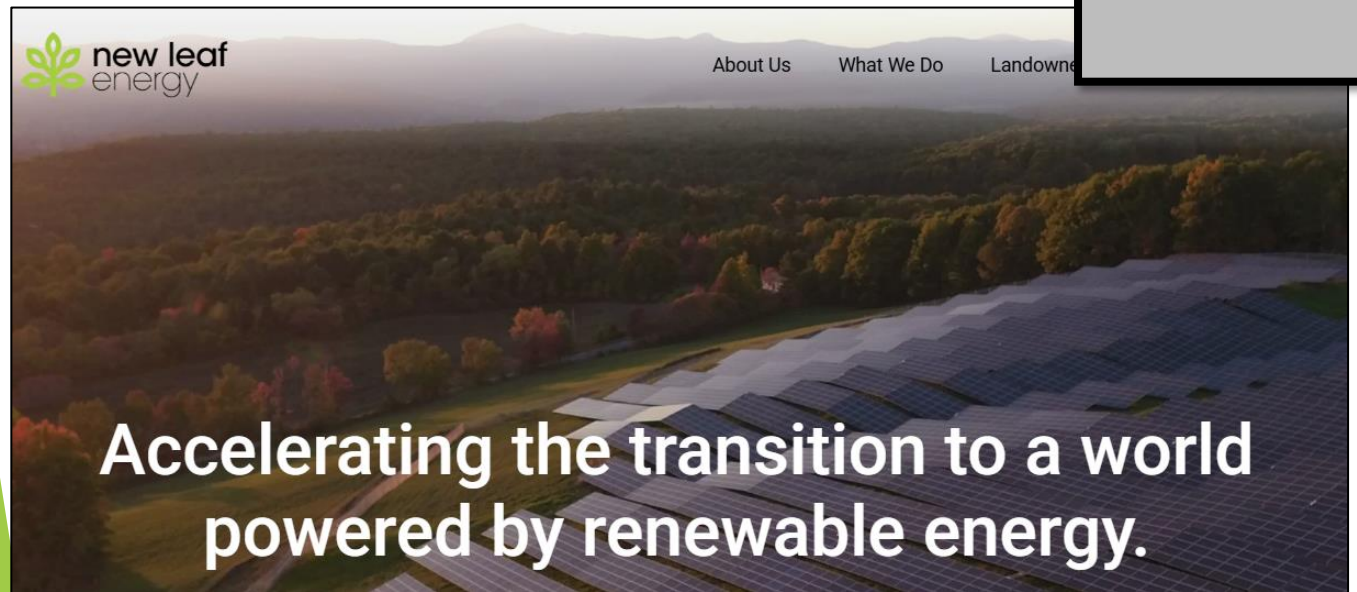


Outdoor wind lab with a Bergey, Skystream, and MET tower for experiential O&M, analytics, and tower training

Intro

- Joined NLE in 2022
- Manage U-S PV/BESS and DG wind design engineering teams
- Projects developed in 21 states (current installed map to right)
- Pureplay developer (mostly)
- Projects from 5 to 500 MWAC



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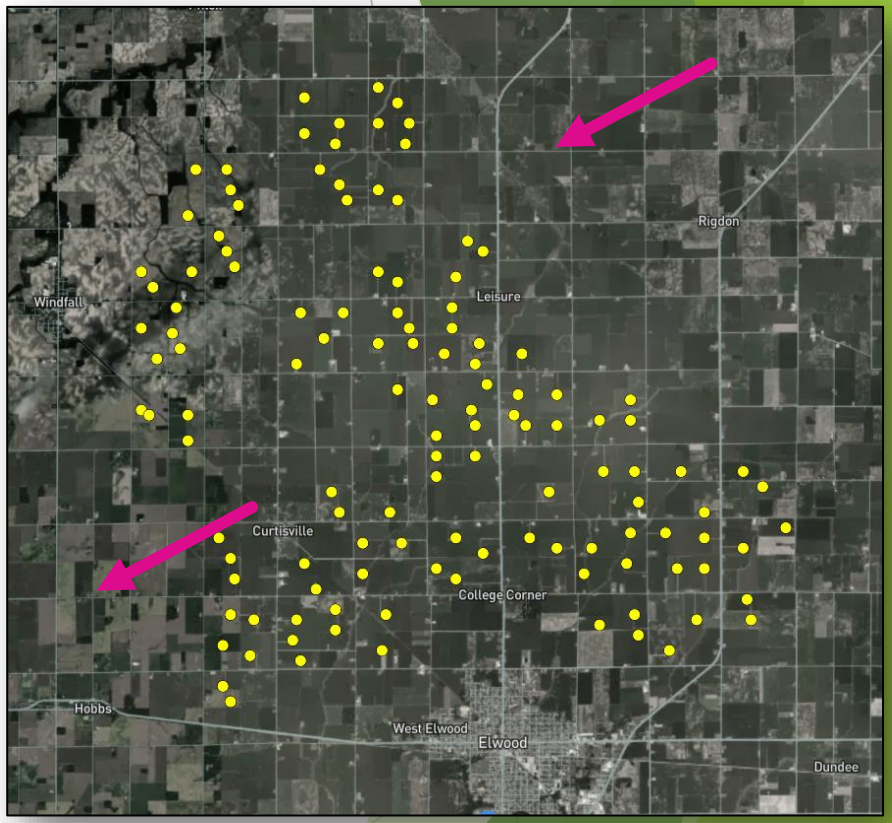
Our general strategy:

- Prospect for "have-nots" adjacent to existing wind farms
- Consider the local climate toward wind development
- Consider the distribution network
- Consider the wind resource
- Might it be viable?



Typical process gates:

- Landowner lease agreements, real estate, legal…
- Interconnection application and initial design
- Local permitting
- Met data, site suitability, production modeling, valuation
- Find a buyer (typically IPP or EPC)

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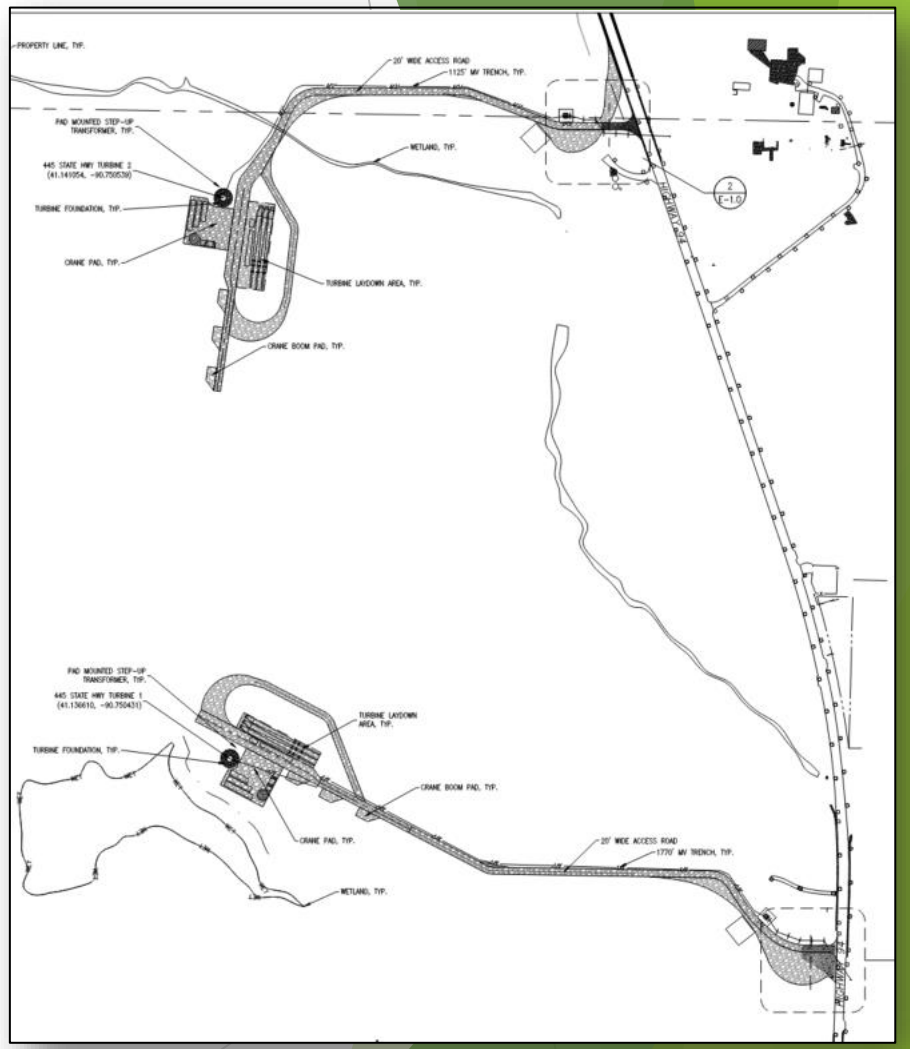
Permitting challenges

- We develop in a gray area…
- Need a met tower (but what height?)
- Max DG POI capacity for many states is 5 MWAC
- One or two turbines per site (but a unique POI for each)
- Full site diligence (Geotech, wetlands, T&E, bio surveys, etc.)
  - Basically, wind farm permitting for single turbines
  - Lighting and curtailment for single turbines ($$)
- Transport studies



How is this a good idea?

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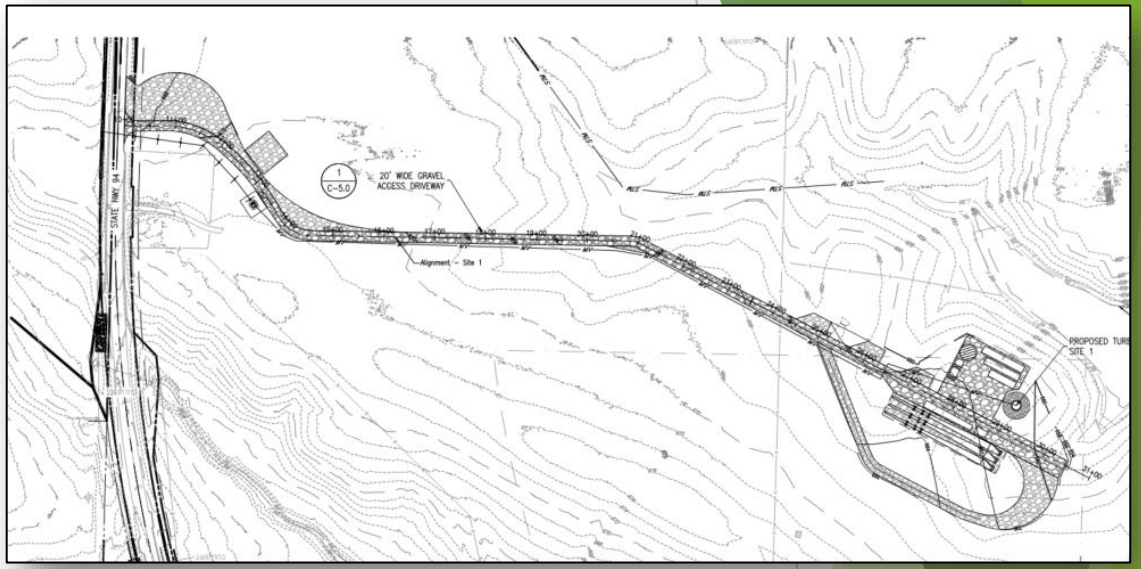
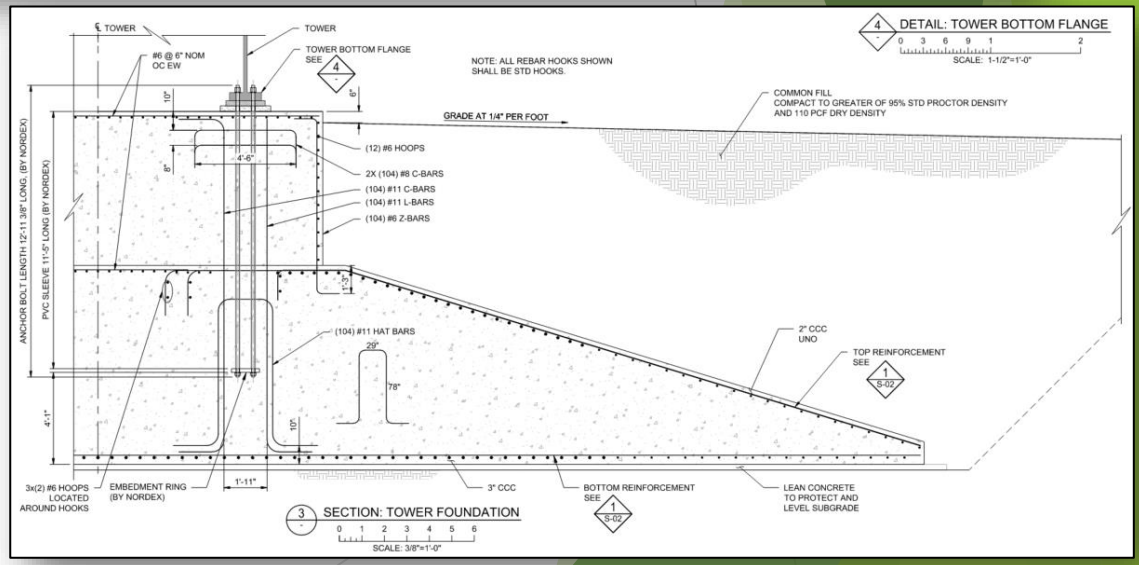
Civil challenges

- Grading plans
- Compaction plans
- Stormwater protection plans
- Turn analysis (beyond transport study)
- Foundation plans
- FAA permitting
- Risk vs. reward of permitting 60m met masts
  - Generally easy to permit and not permanent
  - Not the ideal height for 5MW machines
  - Lidar units?





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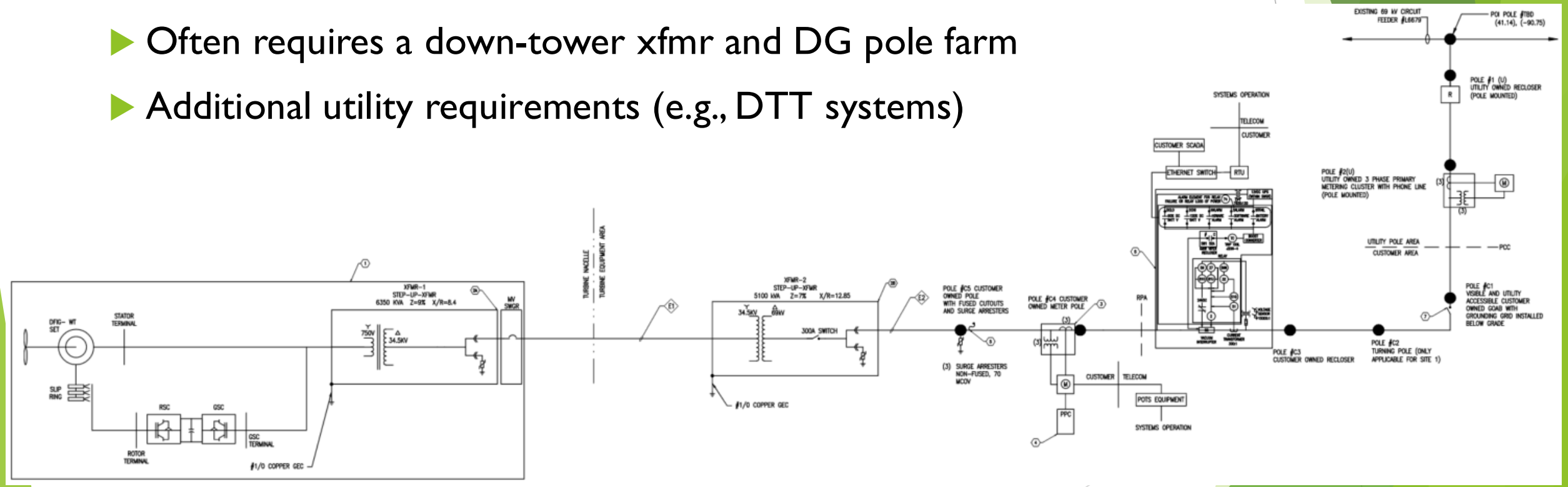
Electrical integration challenges

- Targeted distribution voltages (13kV, 25kV, 34.5kV, maybe 69kV)
- No 34.5kV collection system or substation (not a wind farm)
- Often requires a down-tower xfmr and DG pole farm
- Additional utility requirements (e.g., DTT systems)



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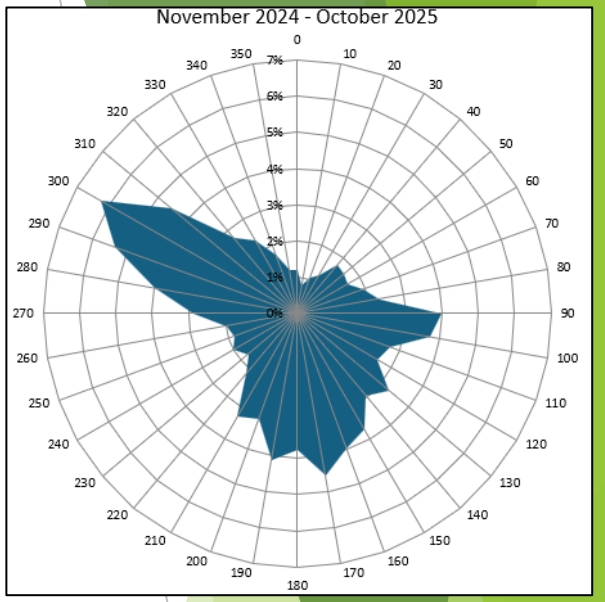
Wind analytics

- 12 months of wind data is typically needed
- Greatly affects project timelines (compared to PV and BESS)
- Preliminary resource assessments (done internally with inexpensive data)
  - Key for initial turbine siting and permitting
- Independent engineering reports on turbine site suitability
  - Aim for 6 months of site-specific data
- OEM site suitability report required for turbine sale agreement
- 3rd party production modeling required for bankability



Turbine Row Orientation, Degrees True	Spacing between turbines in rotor diameters (meters)...					
	1.5 (244)	2.0 (326)	2.5 (408)	3.0 (489)	3.5 (570)	4.0 (652)
360/180	16.20	9.83	6.62	4.94	3.83	3.12
010/190	15.14	9.17	6.14	4.55	3.50	2.84
020/200	14.08	8.52	5.74	4.28	3.31	2.69
030/210	13.09	7.91	5.33	3.99	3.09	2.53
040/220	12.35	7.37	4.93	3.66	2.83	2.30
050/230	12.00	7.05	4.66	3.42	2.61	2.11
060/240	12.57	7.17	4.66	3.45	2.65	2.15
070/250	14.07	8.11	5.26	3.84	2.92	2.35
080/260	16.52	9.81	6.49	4.77	3.64	2.94
090/270	19.47	11.89	8.06	6.03	4.69	3.84
100/280	22.04	13.81	9.50	7.15	5.58	4.57
110/290	23.49	14.92	10.33	7.74	6.02	4.92
120/300	23.69	14.81	10.21	7.70	6.03	4.95
130/310	22.64	13.88	9.42	7.04	5.46	4.46
140/320	21.10	12.67	8.43	6.21	4.75	3.83
150/330	19.54	11.65	7.72	5.70	4.37	3.54
160/340	18.24	10.97	7.40	5.54	4.31	3.52
170/350	17.11	10.46	7.10	5.30	4.11	3.35

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Working with vendors and buyers

- Most don't "get it" initially
- Many wind veterans are comfortable either with smaller DG projects or larger wind farms
- Turbine vendors want project volume to make it worth their while
- EPCs want multiple turbines for logistical/cost efficiency
- IPPs need to determine value and devise maintenance plans
- Utilities rarely see 5 MW machines connected to distribution lines in front of the meter
- Wind analytics vendors use overly complex modeling for single turbines with minimal mesoscale requirements

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My Advice:

Don't do this.

Really.

(Unless you LOVE wind and can convince others

it is a good idea that will eventually make money)

Thank you!

Peter Odren
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