

Wind-Energy Weather Module E (Sample) - page 1 of 3. Steps 1-4.

1 Scenario / Narrative

You are the manager of a wind farm. The blades on one of your wind turbines was damaged and needs to be replaced with new blades. Even though the replacement turbine blades are expensive, you have a spare set of new blades at your wind farm that you can use. Meanwhile, you stopped that one turbine so that the damaged blades would not destroy the whole turbine (pedestal, generator, transmission, etc.).



You need to hire a very large crane to remove the old blades and lift the new blades. Given the remoteness of your wind farm, you need to call the crane company today so they can get to your farm by tomorrow morning. But these big cranes are very expensive, and you need to pay their fee every day they are at the wind farm, regardless of whether they replace the blades or sit idle. These very tall cranes are sensitive to winds, so the crane company refuses to operate when wind speeds at hub height are unsafe. The max safe wind speed is 5 m/s.

Every day that the damaged turbine is not generating electricity costs you lost revenue. The shareholders of the company you work for cannot tolerate lost revenue, because the company is still paying substantial interest to the bank for money they borrowed to build the wind farm. The Chairman of the Board of your company putting pressure on you to replace the blades as soon as possible.

Today, you are trying to decide whether to replace the blades tomorrow. Although winds are expected to be too fast most of the day tomorrow, there appears to be a period of opportunity in the late afternoon when wind speed is expected to be 4 m/s. But there is a slight chance that the winds might be faster during that period. If you don't replace the blades tomorrow, your next period of opportunity with safe winds are two days after tomorrow.

What should you do? Consider only the following options:

- A) Start the damaged turbine and continue running it without any repairs.
- B) Book the crane to come tomorrow, because the wind forecast looks good. If you cannot replace the blades tomorrow, have the crane stay on site two additional days until the winds are safe.
- C) Book the crane to come tomorrow, because the wind forecast looks good. If you cannot replace the blades tomorrow, release the crane to return to its base, but book them to come back two days from tomorrow.
- D) Wait until two days after tomorrow to have the crane come for that one day and replace the blades.
- E) Bribe the crane operator to replace the damaged blades tomorrow afternoon even if the wind speeds are too fast.

2 Access to Related Info

Crane rental cost = \$80,000 / day.	Lost Revenue of not operating = \$2,500/day
New turbine blades cost = \$970,000.	Cost of whole turbine with blades = \$4.5M.

3 Your Weather Queries

Often, the first step to making a good decision is knowing what questions to ask regarding the weather. Your assignment: What questions do YOU want to ask, to help you make the best decision?

Select the following quiz link in Canvas to enter your questions: [Wind-Energy E - Step 3](#).

(Note: None of the links are active in this sample.)

4 Meteorological & Other Concepts

Instructions: To help you make a wiser decision, please access each link below to learn how the weather works, and how it affects your activity.

- Start on row 1, and work left to right. After you have studied all the concepts on that row, do the quiz listed at the end of that row.
- Then do the same for row 2, etc.

Note, each quiz will take you out of this Module. When you finish the quiz in Canvas for any row, you should return here to work on the next row.

Row	Topic (& learning goal)	Topic (& learning goal)	Quizzes Online
	<small>(Note: None of the links are active in this sample.)</small>		
1	Numerical Weather Prediction (NWP)	Ensemble NWP	Wind-energy E - Quiz 1
2	Ensemble Average	Probabilistic Forecasts	Wind-energy E - Quiz 2
3	Cost-loss methods	Cost-loss example	Wind-energy E - Quiz 3

After you have completed all the quizzes AND after the deadline for page 1 is reached, you will be given access to page 2 (steps 5 & 6).

Use the info and links below, along with the fundamentals you learned in Step 4, to help you make a decision in Step 6.

5 Weather Data Available Today

5a. Data Available Here is the calibrated probabilistic wind forecast available today for winds over the next 3 Days. The green line is the ensemble average wind (= best deterministic forecast).

Satellite Observation	Radar Observation
NWP Ensemble Forecast	Other Data

5b. Teamwork Discuss with your team the strategy you will use to analyze the info to reach a decision.

6 Computations & Analysis

Computation Exercise Statement
Headstart Info & Tips
Online Quiz : students submit their code, calculations, and quantitative answer.

7 Your Recommendations / Decision

Options to Consider:

A	Start the damaged turbine and continue running it without any repairs.
B	Book the crane to come tomorrow, because the wind forecast looks good. If you cannot replace the blades tomorrow, have the crane stay on site two additional days until the winds are safe.
C	Book the crane to come tomorrow, because the wind forecast looks good. If you cannot replace the blades tomorrow, release the crane to return to its base, but book them to come back two days from tomorrow.
D	Wait until two days after tomorrow, to have the crane come for that one day and replace the blades.
E	Bribe the crane operator to replace the damaged blades tomorrow afternoon even if the wind speeds are too fast.

In real life, sometimes there is not a "perfect" decision, because of uncertainties in the weather. Your job is to try to understand the underlying principles at play and scrutinize the information provided to make the most reasonable decision, given the uncertainty.

Decision: Make your decision regarding the options listed above.

[Wind-energy E - Step 7a Decision - quiz](#) .

Justification: Enter a one or two paragraph summary of what you considered to make your decision.

[Wind-energy E - Step 7b Justification - quiz](#).

(Note: None of the links are active in this sample.)

(You can also find these two quizzes listed in the Assignments tab in Canvas.)

8 Actual Outcome

The winds were observed to be 5.5 m/s at the start of the period of opportunity. You convinced the crane operator to replace the blades anyway. The old damaged blades were removed successfully. But while lifting the new blades a wind gust caused the crane to tip to the side. To prevent the crane from falling over, the crane operator released the new blades, which fell to the ground and were totally destroyed. Luckily, no one was hurt.

The crane operator was fired by the crane company. A legal investigation was made of the incident. You were found to be at fault. You were fired, and your professional license was revoked.

Related Stories

- Video of turbine destroyed in high winds.
<https://www.youtube.com/watch?v=af9Mm5nkNAQ>
- Video of crane lifting a turbine blade.
<https://www.youtube.com/watch?v=xYass9mVzU8>
- Video of technicians rappelling to repair a blade.
<https://www.youtube.com/watch?v=iwHpGw665NA>



9 Thoughts by Experts

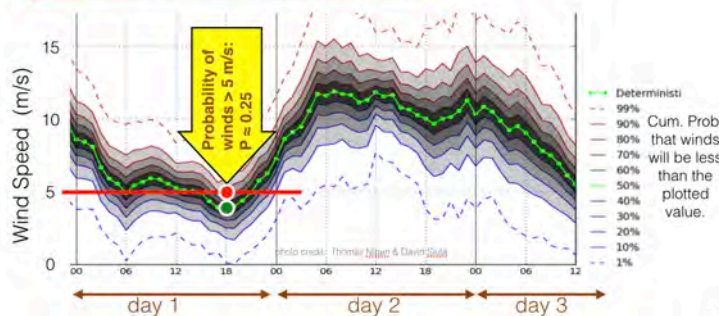
Solution:

Cost to protect the blades (postpone the replacement) ≈ \$165k.

Loss if blades damaged during attempt ≈ \$970k.

Cost/Loss ratio $R \approx 0.17$

$P > R$. Therefore do not replace today.



Scientist Spotlight

Thus, even though the ensemble-average (i.e., best) forecast is for winds to be slower than 5 m/s in the afternoon on Day 1, the chance of faster winds is too large, given the great expense if the blades are damaged.

The optimum solution is **not** to hire the crane to come on Day 1. Instead, re-evaluate the forecast as Day 3 approaches, and book the crane if appropriate.