

## UNITED BY THE WIND

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BEATRIZ (MODERATOR): The wind has always been there with us... From the beginning of time... It is an essential component of the life cycles of hundreds of plants and animals that couldn't live without it... The wind is one of the fundamental factors that explain life and the planet's ability to function, but... What do we know about it?

*(Music playing and voice-over: "United by the wind")*

MODERATOR: To learn a little more about this fascinating topic, we've invited three experts on the podcast: Concepción Camarero (CONCHA), geographer and professor at the Autonomous University of Madrid; Irene del Río, journalist specialised in meteorology; and Luis Prieto, physicist, and the head of meteorological forecasts at Iberdrola... hello, how are you?

*(Guests say hello)*

MODERATOR: For hundreds of years, human beings have taken advantage of the power of the wind to navigate and discover new lands. Concha, am I right about that?

CONCHA: All major civilizations have used this phenomenon to move about, trade with sometimes far-off lands, and conquer them. From the Greeks and Phoenicians to the Vikings... Great navigators. They didn't just make inroads into Europe, they also probably reached North America. In fact, some think that they were the first Europeans to set foot on the continent, some 500 years before Christopher Columbus, when he got there, returned to Europe, spread word about its existence, and established a route based on knowledge of the Atlantic winds.

From then on, Spanish, Portuguese, and British ships were able to use the winds of the West, the trade winds, and the winds of the South to travel between the different oceans, leading to what would be called "the first globalisation of the planet" after the famous Spanish navigator's Magellan–Elcano circumnavigation came to a close in 1522.

MODERATOR: Irene, these southern and trade winds were quite influential then, but still are today, isn't that, right?

We have started to dive into the central role of the wind throughout history, but perhaps we should first clear up what we're talking about and what we mean when we talk about this meteorological phenomenon.

IRENE: The first thing that I would like to emphasise is that the wind and air are not the same thing, even though it is often true that we use both words interchangeably.

Air is a gas formed mainly of oxygen, nitrogen, and other elements such as carbon dioxide or water vapour. It is what the earth's atmosphere is made of. For its part, the wind is that same air in movement.

The second thing we should clarify is that there are different types of wind. Specifically, there are 3; planetary, regional, and local... but let's not bore listeners with a lot of definitions.

MODERATOR: It's not boring at all, just the opposite... Here, we're going to talk about this third "leg" of our topic, which is how the wind generates part of the electricity that we enjoy today.

LUIS: We're talking about wind energy of course. We have been using wind energy from the wind to our own benefit for centuries, from powering our windmills to grind wheat to wind turbines that we use today to generate clean electricity. In fact, this is one of the fastest growing type of energy source in the world.

*(Music playing)*

But let me say something else... These wind turbines use the same effect that makes it possible for planes to fly, the lift. Thanks to this effect we are able to transform wind into rotational movement, and that rotational movement is what lets electric generators transform this energy into electricity.

MODERATOR: Let's focus a little bit on the role of wind in meteorology, yeah? And we're going to do that by hearing a little more about the history of forecasting, from its origins in the world of superstitions, beliefs, and folk wisdom, to the scientific and technical explanations that we use today.

*(Music playing)*

CONCHA: It is widely known that western science was born in Greece. That was also the case with Meteorology, the science that studies atmospheric phenomena, including the wind.

Its name comes from two Greek words: Meteoros, *μετέωρος metéōros*, in singular, or meteora in plural, meaning "things above or in the air", and *logos*, meaning "to study or address something". Aristotle lived in the 4th century before Christ, meaning nearly 2,400 years ago, and used the term to *Μετεωρολογικά*, or *book of the meteorologists*, as the title of his work. The Greeks were the ones to move from superstition, in some cases, or mere empirical knowledge, to scientific knowledge. Wind was a part of this process, and was a key component of their economy, which was based on trade and navigation. This is shown, for example, by the existence of the Tower of the Winds, located at the base of the Acropolis in Athens.

IRENE: But apart from scientific history, throughout the years, those dedicated to professions depending on meteorological conditions soon became experts on the weather. Clear examples are the sailors and shepherds that made their own forecasts based on their observations of clouds and the wind.

In fact, one of the first written meteorological forecast to exist was written in England and dates from 1670, if you can imagine... "The Shepherd's Legacy" it's called, and it contains a multitude of predictions based precisely on that... Studying the different atmospheric phenomena.

MODERATOR: In this sense, it should also be noted that popular knowledge has always been there and remains patent in our collective proverbs. Just to give an example that may not be so well-known: "When the wind is out of the East, 'tis never good for man nor beast".

IRENE: And let me add one more: "Red sky at night, shepherd's delight. Red sky in the morning, sailor's warning".

Fortunately, numeric models have been used now for many years, with weather and climate forecasts being more exact and therefore much more reliable... But that doesn't mean that you won't hear these kinds of sayings between neighbours in small towns.

LUIS: Talking about meteorology, one of Iberdrola's fundamental components is the weather forecasting, and in this case the wind forecasting. To know in advance the wind of our facilities is beneficial in two different ways. Firstly, it lets us plan maintenance in our wind turbines under low wind conditions and therefore, underknown of very low production. This minimises the impact of stock the production.

Secondly, all generating technologies must anticipate their production in the electricity market and this market apply you economical penalties if you don't comply with your forecast,

So, as higher is your precision of the power forecast, the higher the benefits of your wind farm because of your lower penalties. This is also important on a global level, the wind industry's ability to predict wind production in advance, will let to a more capacity of the system to absorb wind energy, in other words, the improvements in the wind forecast are a key factor to convert the wind energy into a fundamental power source in a country's energy mix.

And I don't want to brag but at Iberdrola, we have a forecasting system call MeteoFlow that has been developing for more than 15 years. It combines the best meteorological models with the latest artificial intelligent techniques to provide the most precise forecasts at our facilities.

MODERATOR: I don't know if artificial intelligent was used to talk about this interesting thing that caught my attention when I was researching for this podcast, but in the many stories I saw, I found this one that I want to share with you, which is that if the wind disappeared from our lives, it would take the equivalent of nearly 7 million atomic bombs to get its movement back, which I thought sounded like science fiction.

CONCHA: Well, as in science fiction, the wind was actually at the centre of many historical events.

For example, during the Second World War, the knowledge, or lack thereof, about the system of winds at mid-latitudes was key to the success of aviation and survival of the pilots. Europeans and Americans didn't know about the existence of the Jet Stream, which made certain points of Europe impossible to bomb or lead to experienced pilots dying under enemy fire.

On the other hand, Japanese knowledge helped them bomb the US without messing up their hair, if you will excuse the expression, by using unmanned balloons loaded with explosives that "rode" this current when they rose, carrying them to the United States, where they dropped their deadly cargo.

We now know that this area of strong winds is found at a height of between 8 and 10 km, circulating from West to East, which is taken into account when designing any kind of aircraft flight plan. It's faster to fly from Europe to America than it is to return, which is "against the current".

IRENE: We shouldn't underestimate the power of our dear friend the wind. I don't know if you or our listeners have asked yourself if we could fly away from its force... The experts have done

it, and they have also proven that a man of average size could start to be swept off the ground at winds of about 140 km/h, and if they reached 150 km/h, he would literally fly away.

Another bit of info I wanted to add that really surprises everyone is that the strongest gust of wind recorded to date... at least as far as we know... reached 408 km/h. This happened during cyclone Olivia in western Australia on Barrow Island in 1996.

LUIS: Since we're talking about speed, I'd like to mention that the strongest winds are NOT the ones that produce the most electricity. While it may seem counter-intuitive, this fact is based on the wind turbine's own safety. It's true that electricity production increase with the wind speed but above a certain maximum wind speed, power generation remains constant.

Even more, there is a safety threshold above which the machine slows down to protect itself and avoid structural problems, since it could collapse.

Don't you know how turbine stop with high winds? Well, the turbine turns the blade to eliminate the lift effect and the blade stop rotating. We call it to "put the blades in flag position". In general, wind turbines produce energy at wind speeds of between 3 and 25 m/s (although these values depend on each specific wind turbine model). This is the equivalent to 10 and 90 km/h.

Another curious fact is the blade tip speed. While it may seem like wind turbine are rotating slowly, the blade tip, in the biggest models, reach a linear velocity of more than 350 km/h.

MODERATOR: But what happens if the wind isn't blowing, Luis?

LUIS: When the wind is below the minimum value of 10 km/h, it stops rotating and doesn't generate electricity. One of the tasks carried out by specialised teams like we have at Iberdrola is finding and designing wind farm locations trying to minimise stopached periods and generate as much energy as possible. To do this, this knowledge of local and regional meteorology is needed to find optimal locations to maximise production.

*(Music playing)*

MODERATOR: Oh, we haven't talked about how the wind is measured, who wants to tell us about that?

IRENE: I will. Wind is measured using the Beaufort Scale, which was created in 1806 by Sir Francis Beaufort, who was a naval official and hydrographer. It's based on the state of the sea, its waves, and the force of the wind. The scale goes from Beaufort 0, which represents calm... with 0 knots, from 0-1 km/h, then come breezes which would be winds of up to 50 km/h and get a score of up to 6, and up to a score of 12 are strong winds and storms. The maximum is 12 with winds of more than 118 km/h, after which we would be talking about hurricane-force winds.

As we all know, when we are talking about hurricanes, the strength of the winds is so powerful that it can destroy entire cities. Remember that hurricane Katrina blew away part of New Orleans in 2005, just like the Calcutta cyclone, which was described as one of the "deadliest natural disasters of all time". It actually killed more than 300,000 people when it made landfall in 1737.

And also, we can't forget about disasters caused by typhoons, that leave devastation in their wake with landslides and floods... They have also taken thousands of lives over the course of history.

CONCHA: Let me interrupt you here, Irene, because since you brought up typhoons, I wanted to mention that kind of wind in Japan that is called "kamikaze", which translates to "divine wind", because two major typhoons stopped the Moguls from conquering the nation back in the 1280s and the Japanese believed that the winds had been sent by the gods to protect them.

LUIS: Continuing on with some historic details, it looks like the wind energy has been developed in recent years but that is not the case. The first home to be supplied with electricity from wind energy dates back to 1887 in Scotland. And before that, the first windmill on record date back to the 9th century in Persia, although some researchers think it could have been one or two centuries before.

MODERATOR: Well, let's bring it back from history to present, because I see we are running out of time and there is still so much more to say about wind. We can do that by picking back up with those interesting facts about this phenomenon, as Irene had mentioned just as we started the podcast when she mentioned the presence of wind in outer space.

IRENE: Yes, of course, there is also wind in outer space. In fact, the so-called solar wind is a stream of particles that come from the sun. And on Saturn and Neptune, we find the solar system's fastest planetary winds.

If you will let me add one thing, another "superpower" of the wind is that it can drastically change the temperature of the environment, both raising and lowering it. Once again, I'll give you an example to better understand things...

In the cold winter months of regions east of the Rocky Mountains, a strong, dry, warm wind sometimes blows from the mountains across the land. Known as Chinook, this wind can bring quick temperature changes.

Chinook winds develop when warm, moist air blows from the Pacific Ocean in the northwest region of North America toward the Rocky Mountain. The air mass cools as it climbs the mountains, bringing rain or snow to the peaks. The air mass, now dry after releasing its moisture in the mountains, warms as it moves down the eastern side of the mountains. The air mass warms rapidly, eventually becoming warmer and drier than the original air mass coming from over the Pacific Ocean. When the winds suddenly change direction toward the west or southwest, the Chinook winds begin with rapidly increasing speeds.

Chinook winds can be as much as 10 degrees Celsius warmer than the air they displace.

CONCHA: So, Irene, we need to talk about the consequences of haze, at least for us humans, which is quite frequent in our country and has an impact on our health. I will say that few of us remember the benefits of those orange skies for the planet, which act as natural fertilizer. You heard that right.

For example, sand carried from the Sahara has a lot of oxides and carbonates, as well as large quantities of phosphates, which are important compounds for agricultural fertilizers. The wind

is precisely what is responsible for bringing millions of tonnes of compounds from the Sahara Desert to far-off lands every year. This was also the case in ancient times when these types of materials, called loess, were transported around the planet, leaving deposits forming extremely fertile spaces like the plains of central Europe. Without the wind, black soil would have never come to exist in Ukraine and Hungary.

IRENE: The strength of the wind is capable of sweeping up particles, particularly dust and sand in the form of haze, as Concha has said, which can reach the far corners of the Earth, and even move large quantities thousands and thousands of kilometres away. Proof of this is the Saharan sands that you mentioned, which can cross the Atlantic and create a sort of cloud that leaves skies foggy... It doesn't just reach the peninsula... Sometimes it even moves into central Europe and all the way to the Caribbean.

The wind doesn't just carry dust... It can also transport volcanic ash. This happened in 2010, when the Eyjafjallajökull volcano, in Iceland carried a huge cloud of ash to Greenland and Great Britain. You will recall that it paralysed air traffic throughout a large swath of the continent for about a week.

MODERATOR: No, we haven't forgotten, and all of that thanks to the effect of the wind, an element that is quite well-known by not just sailors and sailboat captains, but also athletes that make use of it for sports like windsurfing or paragliding.

LUIS: You know, we can also find wind farms at sea. Today, they are still a minority in the industry, but the marine wind energy sector is experiencing a strong growth. The fundamental reason for this is that the wind speed is higher over the sea than over the land. Mountains and vegetation "slow" the wind at the lowest layers of the atmosphere, but this friction is extremely low at sea. So, this higher wind speed at turbine height produces more electricity and compensates the greater difficulty and cost of this kind of sea-based installation.

MODERATOR: Just as fast as our time here on this podcast has gone talking about the wind as a phenomenon present in the before, during, and after (certainly) of our lives. Concha, Irene, and Luis, thank you so much for having shared your experiences and knowledge on the subject, and we hope to hear from you again soon.

*(Music playing and voice-over: "United by the wind")*

*(Guests say thanks and goodbye)*