

[Conversation #4] - On (green) hydrogen: production, challenges and opportunities

In this episode, we speak with Bianca-Rita Pistillo, Partnership Development Officer at LIST, about how researchers are tackling the challenges in hydrogen production and looking into new and sustainable ways of producing the fuel, which holds significant promise as a clean energy source.

Paramita Chakraborty

Hello and welcome to Tech Advantage, a podcast from the Luxembourg Institute of Science and Technology. Two of the most critical challenges facing societies today are identifying and establishing sustainable energy systems. In this context, low carbon hydrogen holds significant promise as a clean energy source. Hydrogen is the most abundant element in the universe, boasts clean combustion, as it is extracted primarily from water and has the highest energy density per unit mass. You'd say what are we waiting for then? Well, there are still some challenges for an economy to become entirely hydrogen dependent, including its production and its storage. Today to talk about these challenges, but especially how we can overcome them, we have with us Bianca Rita Pistillo, Partnership Development Officer here at LIST.

Welcome Bianca Rita.

Bianca Rita Pistillo

Hello Paramita. Hello, everyone. Thank you for this invitation.

Paramita Chakraborty

Thank you for accepting this invitation. First of all, what is your research area? I mean, what was your research area?

Bianca Rita Pistillo

As you mentioned, I'm currently partnership development officer and I'm in charge of the topic of energy and clean tech topics. I'm currently in charge of setting up the collaboration with companies around the topic of hydrogen, energy and clean tech, because my background as a senior scientist was to lead these kinds of projects. So, I can figure out how difficult was reading the paper I sent you. But my new role is also... one of my missions is making it easier the understanding of the research we currently run at LIST.

Paramita Chakraborty

So, to start off... before going into the production, hydrogen production, you know, the topic at its core, why do we need to produce hydrogen as a significant energy source?

Bianca Rita Pistillo

Because we need to have renewable energy sources. Because the fossil fuels, the current fossil fuels will not be enough for the incoming years.

Paramita Chakraborty

And I'm guessing also because... probably it's not just that it's not enough, but they have adverse effects, right?

Bianca Rita Pistillo

Definitely, definitely, there are several aspects of the production of the hydrogen. Firstly, as fuel itself. And then we would like to reach a point where most of the hydrogen production comes from renewable sources and the hydrogen product is green hydrogen.

Paramita Chakraborty

What do we mean by green hydrogen?

Green hydrogen is hydrogen produced by renewable energy and not as it is currently done by fossil fuels. Hydrogen that is produced currently, most of the production of hydrogen comes from the reforming of the fossil fuel. So, we have a current production of hydrogen, but it's not green. And we have identified a series of colours linked to the way that the hydrogen is produced. So you can have violet hydrogen, yellow hydrogen for you can produce hydrogen from nuclear energy. And these kinds of hydrogen are labelled as yellow hydrogen.

Paramita Chakraborty

Yellow hydrogen, but it's still clean, right? Or it's not...

Bianca Rita Pistillo

The hydrogen itself is clean, but the way it's produced is not clean. So the final aim is to find a way to produce the hydrogen in a green way.

Paramita Chakraborty

What are the challenges really right now to produce hydrogen?

Bianca Rita Pistillo

As mentioned, the hydrogen production itself, it's already a challenge, because now we produce the hydrogen via fuel cells. So, producing the green hydrogen is the real challenge for this energy transition to answer, to fit, what is required by the Commission for 2030 and then reaching 2050.

Paramita Chakraborty

And you mentioned a little bit already you know, the current trends and technologies that are being used, but apart from these, are there any other ways that are hydrogen produced right now and are there any other ways that we are envisaging to produce hydrogen?

Bianca Rita Pistillo

For sure we are exploring new technologies for producing hydrogen. Currently, it can be produced by water splitting. But, in case of water splitting we also have to think about the raw materials that are used for setting up the cells that allow the water splitting. We need currently some materials that have been identified as critical materials for energy for instance, the Commission has provided a list of materials, and I can mention the well-known nickel, platinum. We also have neodymium. So, it means that we found these materials in the nature, but the source of these materials is limited. So, we need new materials in order to produce hydrogen.

Paramita Chakraborty

How do you define materials to produce hydrogen?

Bianca Rita Pistillo

For water splitting, we need photo electrodes and the way these photo electrodes are made can change. So, we can have a bar of pure metal, which means that we need 100% of these metals or we could have a bar consisting of nanoparticles, which means that the amount of the metals that is required is lower, and we can and this is the exercise we have to keep in mind to think about new materials. So, we want to keep the functionalities, the properties of the materials, but we want to change often how much is loaded in terms of metals, for instance these kinds of metals. So, if in the past, we could count on a bar of platinum, now we can count on materials where platinum is present as nanoparticles. So, just to give you an idea, so the surface area is high, but the amount of materials is low, because if you have a bar, you have just a surface which is exposed to your reaction, but you have nanoparticles that have a higher surface exposed to the reaction.

Paramita Chakraborty

Okay, so and very, very naive question probably. So these bars of whichever materials we're talking about, how do you produce I mean, you do water splitting... how do you produce the hydrogen from that platinum bar?

Bianca Rita Pistillo

You have two electrodes. And you have water. You apply current to the electrodes. And then, for example, you have platinum as a catalyst. So then there is the splitting of the water and then there is usually one tube... you collect hydrogen in one tube, you collect the oxygen in another.

Paramita Chakraborty

How much could you collect from... what is the amount of hydrogen that you can collect?

Bianca Rita Pistillo

It depends on the power you apply, the size of the cell.

Paramita Chakraborty

What are the applications of hydrogen as an energy source? Can we use hydrogen for everything like we were talking about hydrogen-based economies...

Bianca Rita Pistillo

During the last hydrogen week, I attended in Brussels, and we had a booth as LIST. People approached us to, because they are thinking how to use hydrogen as a fuel for our home heating system, for instance. So it means that in the future, not so long, in place of using methane for heating your house, you will use hydrogen. So it's a real source of fuel. It's already the case for some cars, like Toyota...

Paramita Chakraborty

Exactly, the tank is, is a hydrogen tank. Yes.

Bianca Rita Pistillo

So, you have the hydrogen tank, you have the hydrogen, and the hydrogen allows the mobility of the car.

Paramita Chakraborty

Talking about you know, because we are actually going into the research bit now. So, if you could just tell us about the current research projects that are going on within LIST and maybe later on you know, in Europe or in the world...

Bianca Rita Pistillo

So, in LIST, we are focusing on several parts of the entire hydrogen value chain, we have several projects and several teams who are currently working on the hydrogen topic... on production of hydrogen as well as on the storage of hydrogen. If I have to say a few words about the ongoing projects on the production, we are one of the few laboratories in Europe, who demonstrated the fuel cells can work... we can produce fuel cells with high power, but very low loading of metals as I mentioned before, we also have a team who's working on the synthesis of polymers that can act as photocatalysts and they are based on porphyrin which is part of the chlorophyll. It is a molecule similar to the family of chlorophyll, but we also work on harvesting the energy. There was a technology developed in LIST based on where the electricity is produced through a chaotic trajectory pendulum system.

Paramita Chakraborty

What is that?

Bianca Rita Pistillo

You have a system that you can put in the water especially in the ocean or in seas.

Paramita Chakraborty

Is it that you know like in Luxembourg Science Center I saw they have these pendulums and then you can do is that...

Bianca Rita Pistillo

It's kind of a whirlpool. Okay, so basically, you have a sphere, we have the first gen of this technology. It's a sphere that can move according to the waves, the movement on the waves. And thanks to the technology behind there is a transformation of the movement or the mechanical energy into electrical energy. And if you coupled this system with an electrolyser, you could produce hydrogen. It's definitely something fascinating,

Paramita Chakraborty

So, that is going on at LIST right now. And are there you know, so, this is the cutting-edge technology right now to produce hydrogen... are there any other technologies that are being researched in Europe or in the world?

Bianca Rita Pistillo

This is a quite unique system right. The first gen, the sphere is one meter in diameter, the second gen will be a six meter in diameter sphere. And the idea is to put a fleet close to the Belgian coast and to prove the feasibility of this kind of energy production.

Paramita Chakraborty

While doing my research about hydrogen production, especially here at LIST, I came across a lot about Sibylla lab. If you could just give us an overview, what is Sibylla lab, what is being done there...

Bianca Rita Pistillo

Sibylla lab is a joint lab with 3D-Oxides, a French company. And it's true that Sibylla is quite a unique machine because you can load a 45 centimetres wafer, and it's quite a unique machine, quite unique facilities really close to the industrial approach.

Paramita Chakraborty

And wafers made of what?

Bianca Rita Pistillo

Silicon wafer...

Paramita Chakraborty

Silicon wafers and what do they do the silicon wafers?

Bianca Rita Pistillo

The silicon wafers act as support of the material that you deposit on the top of the wafers. You can use silicon wafers, you can use other kinds of materials according then also to the characterization analysis that you would like to perform. So, for some characterization, you need to have a silicon wafer support for something else you can use quartz.

Paramita Chakraborty

I'm lost, so how is it relevant to hydrogen production?

Bianca Rita Pistillo

In the hydrogen industry, Sibylla could contribute to accelerate the development and the discovery of new materials, because owing to the principal that allow Sibylla to work, so the chemical beam vapour deposition approach, you can deposit materials with different stoichiometric ratio. And this means that these materials also exhibit different properties. So it means that through one experiment, you can get several materials, and with several properties, so in this sense, it allows a really... it can speed up the discovery of the right materials used as photo electrodes.

Paramita Chakraborty

If I'm understanding correctly, it helps in the discovery of new materials?

Bianca Rita Pistillo

Yes, because it's allowing first screening of chemicals. And this is quite unique, because usually, you make the deposition and you carry out the characterization, then you make a second deposition, then you adjust, and you adjust... It also allows the deposition of components that are not allowed by conventional synthesis approaches.

Paramita Chakraborty

One question... when I was reading about the challenges, you know, in hydrogen production and you know, challenges to realize a hydrogen-based economy, one of the things that came up was the cost of production and cost of storage and cost of infrastructure.

Bianca Rita Pistillo

Currently, the cost of hydrogen is higher, or the cost of green hydrogen is higher than the cost of fossil fuel.

Paramita Chakraborty

So, are there any strategies right now that the leaders, the researchers are thinking to decrease the cost?

Bianca Rita Pistillo

The cost of hydrogen is strongly related to political reasons. So, despite the efforts that researchers can make, a lot has to be done by the governments to reduce the costs and also to help companies to reduce the cost in the production of hydrogen. Working on materials where the amount of raw materials is less impactful than currently, will also allow Europe to be independent from other countries, because currently, Europe depends. So, there is a certain vulnerability of Europe. And this is also the reason for which the Commission prepared a proposal for reducing the critical raw materials in the hydrogen industry.

Paramita Chakraborty

So, there is a proposal from the European Commission in that direction?

Bianca Rita Pistillo

There is also a wish of the Commission to make Europe stronger in the face of other countries like China, Turkey, and so on.

Paramita Chakraborty

And how about Luxembourg? Does the government have any sort of initiatives in that direction?

Bianca Rita Pistillo

To me, Luxembourg could play a leadership role, owing to the geographical position, and also the political stability, which is fundamental in this energy transition. So definitely, there is a role that Luxembourg can play in the next 20 years.

Paramita Chakraborty

And lastly, in the next five years, 10 years... what are we looking at if, let's say, for an economy to become completely hydrogen dependent?

Bianca Rita Pistillo

From a scientific point of view, it's really, really optimistic to believe that in 2030, we can switch to hydrogen and reach to fulfil the request that the Commission decided.

Paramita Chakraborty

I just have a question because it's complete out of curiosity, what about the dangers of hydrogen? You know, because we all have heard about the hydrogen bomb. So, are there strategies or are there people thinking about the dangers of hydrogen as an energy source?

Bianca Rita Pistillo

Definitely the danger of hydrogen is much more to me in the mind of people. Because all chemicals present some dangers for sure. And you give me the opportunity to remind another research line we're carrying out at LIST, and it's based on sensors because we are

developing in situ printing sensors to detect any deformation for instance of a hydrogen tank. So, this could be a way I also have to quote or talk of another group who is working on the detection of hydrogen into materials. So, hydrogen could diffuse in the materials, and we also have people in LIST who are working on the detection of this hydrogen. So, as you could see, in LIST, we are very active on different points of the hydrogen value chain not only the production. So, for sure it's new, hydrogen is a new topic and people not involved in science need time to think about hydrogen as something that is not as dangerous as we could imagine.

Paramita Chakraborty

Well, thank you so much, Bianca Rita, I mean... like you were saying probably it's too optimistic to think about the next 10 years, or 20 years maybe but given that technology, how technology has advanced in the past decade, you never know right?

Bianca Rita Pistillo

Thank you, Paramita! I'm also confident that science could go fast. And we will see in five years where we will be.

Paramita Chakraborty

Thank you so much.

So that was Bianca Rita Pistillo, Partnership Development Officer here at LIST talking about the intricacies, challenges and also the opportunities related to hydrogen production. Hope you enjoyed our talk. And as always, see you in two weeks.