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FCHgo! INTERVIEW

Prof. Filippo Sala - Laboratorio Prototipi IIS A. Ferrari
Maranello I.T.S Automotive



Barbara Grazzini (InEuropa srl): Good morning to our guest, professor Filippo Sala.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): Good morning everyone, thank you.

Barbara Grazzini (InEuropa srl): You are a professor in Maranello Technical Institute and a pioneer of the experiments regarding renewable and sustainable energies, you are a very important representant and spokesperson of hydrogen and sustainable energy, a theme we want to talk about in schools, where we need to raise awareness and inform children and teachers implied in their formation and education and in building of our future.

Professor Sala, tell us about your experience in the field of fuel cell technology applications and some anecdotes. What happened? What would you like to tell us?

Prof. Filippo Sala Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): I've been 40 years in Maranello in the Motor Valley, now I start to sum up otherwise we risk talking until midnight. I began, between a mountain hike and another, to teach in an engine workshop in Maranello, the engine temple. There was something coming after the Gulf crisis. I could perceive a very big problem: we were all working on heat engines with a return of 20% and an energy dissipation of 80%. You must forgive me if I use the personal pronoun "I". "I" doesn't exist in Maranello. We talk about tens, hundreds of students, teachers, of a territory made of industries, enthusiasts, "insane", creative and very much prepared people. So, what happened over the last 30, 40 years in the Laboratory Prototype Course where I still work, is a community achievement. And Filippo Sala has coordinated it, without false modesty, for 40 years. We immediately started to realize we needed to substitute heat engines, and not trying to look for new applications, what I wanted was something which could do the same work while saving energy. We can't afford to use engines with a heat dissipation of 80%. Over the first years the course was called Zero Emission Prototype Laboratory. We worked in the homologation of some electric vehicles at the beginning of the 1990s. We must remind that from an educational point of view I don't even feel a pioneer because in that period there was excitement in Italy. Quattroruote magazine of Fiat Chrysler Automobiles N.V. used to organise competitions, gatherings, electric vehicles competitions all over Italy, and we were in the 1990s, even schools participated. I'll skip forward, from those years on there have been talented people and failures, also young people, they all were hopeful. Tens of experiments of industries investing in the first place in electric vehicles, and secondly, in solar vehicles to which we've always been passionate and possessed.

We crossed Australia by solar vehicle in the 1990s. I reached the border of Afghanistan by the electric vehicle Oxiana, as a tribute of The Road to Oxiana by Robert Byron and I was stopped there. We reached North Cape by a pure electric car. The car range was from 150 to 250 km, this was a concrete and prototyped proof. It's an object on wheels moving in Maranello. Then there was the success of the solar car from Onda Solare team at the American Solar Challenge that won against other universities, and this year in Australia our car smashed, but we had very high expectations because it was a four-seater car that could drive thousands of kilometres without needing any charge, this is to give you an idea of how technology evolved. We were considered as heretics in Maranello, I had also been warned.

Barbara Grazzini (InEuropa srl): Tell us about it.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): In Maranello everything is "pulsing and noise". Engines which do not pulse are not real engines. I am still in love with heat engines. Mechanics and fusions, connecting rods, cranks, levers, chains and gear.



Mechanics is a passion. You can work on mechanics without carbon dioxide, gases, NOx and fine dust emissions.

Barbara Grazzini (InEuropa srl): So, you can still have fun.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): I even like cars without taking into account physics. You've already got the idea. You can make totally useless mechanics and yet very funny from an educational point of view to understand motion and its elements because everything relies on just one thing: motion. You can't eliminate motion. Let's make a statement, you can't teach without taking into account motion, starting from entropy is all about motion.

Barbara Grazzini (InEuropa srl): Your experience with hydrogen and the anecdotes you told us in the backstage make us smile if we think about European policies and strategies in the interest of this energy carrier.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): We were zero emission pioneers, and specifically we were pioneers of the electric vehicle as the only alternative and possibility to eliminate heat engines. Everyone, teachers, school curricula, we all must be determined to end the heat era. We burn to eat, we burn to cook, we burn to move, we burn to have a shower, we keep on burning. We haven't evolved that much since the "fire era". Without burning we can't do anything. If I need to travel with a heat engine, I burn, that's why we liked the idea of hydrogen.

Maranello discovered hydrogen possibilities. Also in Turin some engineers were doing some experiments to a Lancia, BMW in Milan and in Germany were involved as well, some experiments were made in Lombardy, also in Mendrisio, and hydrogen started to be considered as a fuel, and for me that was another heresy. Considering hydrogen as a fuel is... hydrogen is flammable, it's an infinite gas, it does not exist in its purest form because it's too light, it can't exist alone if it's not stable inside containers like wood, metal and water.

Barbara Grazzini (InEuropa srl): Professor Romagnoli also said grass.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): Grass, wood is composed of 7% hydrogen, we can find hydrogen everywhere. It is said to be inexhaustible. The sunlight will last only 4 billion years, there's nothing inexhaustible. We must keep that in mind because in 4 billion years' time we will have a problem, both of us. No maybe we won't.

Barbara Grazzini (InEuropa srl): No maybe we won't.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): Nothing is inexhaustible. So, we began to make things clear: nothing must be burnt. Here in Maranello we've excluded every possibility even if it was appealing. I don't want to be that conservative or categorical. There are very useful transition steps. If I can reduce pollution, I won't be a fanatic conservative. Even if I was against hybrid engines from a technological and educational point of view because instead of giving, it takes away, Hybrid engines helped to confirm to many people that electric engines run and work. In the 1990s I couldn't understand how an electric engine could be used to drive even if at home everyone used electric engines: for the washing machine... Everything ran though, but people didn't think it was possible to use it to go somewhere. When we started to work on it and turned on our first prototype, we made a mistake on the gear ratio, which got started and crashed the fence of the laboratory inside the school. It risked killing 4- 5 students. We had not been able to make the right calculations, actually we should have, but my nature, which is not the same of my philosophy, is the reversing project, which means that first we make, from an educational point



of view this is very important, and secondly we plan, or otherwise we plan, we make and then we plan again. Reversing project is my passion. If we come up with something, we make a prototype. Let's do one, be it small, be it big or an experimental model and let's see what the result will be. To do this you must be lucky enough to be in a school like Maranello, like Modena, like Leonardo da Vinci of Carpi because it gave a huge contribution on hydrogen research. Honour to Marco and Stefano of Leonardo da Vinci of Carpi, winners with their hydrogen-powered cars of the Shell Eco Marathon against the major European universities.

Barbara Grazzini (InEuropa srl): Also Leonardo da Vinci of Carpi, definitely.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): We must always recognise who we worked with, multiple times. They belong to our "thermic energy sect".

Barbara Grazzini (InEuropa srl): But when you started to make your first prototype or your first experiment on hydrogen you told us that firefighters took precautions.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): We started with very high expectations, we presented at the Shell Eco Marathon in France, I hope I'm not wrong, 15 years ago, a prototype of a light quadricycle that is still developed today with Milan Polytechnique and Design Higher Education School, we still have it and it produces hydrogen on board. Like an electrolyzer on board. This gives you an idea of the situation of 15 years ago. Also, its wheels were outlawed. During some tests the technical commission rejected every aspect of the prototype. Some articles in French newspapers said that our e-vehicle was the most innovative, but we got rejected... Well. They banned us. We realized a project of a company of which I don't remember the name. We built an electrolyzer, and this is very important, that had two characteristics which are still fundamental today. Teachers must be very careful when speaking about hydrogen because by explaining its accumulation, distribution and applications, it's simple to forget that it is an energy carrier. I don't think that a well-prepared teacher, even with some notions of Physics from middle school can make this kind of mistake but it normally happens also to electric vehicles.

We tend to mistake kilowatt-hour with kilowatt, you can hear it on television and radio where people mistake the measures of energy. We would never say that a tank contains many litres of fuel. But I keep on hearing people referring to batteries with kilowatt measures instead of kilowatt-hour, or more precisely, joules.

We really need to pay more attention. If on one hand a heat engine has a tank containing a big amount of energy, on the other hand an electric car disposes of batteries containing a big amount of energy as well. It's not important if I measure it in kilowatt-hour or in joule. We can't mistake it. Hydrogen is more complex because it's such a light element that it's measured in Normal cubic metres and it must be compressed, which is a problem: the compression of gases needs a huge amount of energy. Moreover, you can avoid compression by using other systems like metal sponges that can hold it, they are precious metals where hydrogen behaves as an energy carrier. For it to be an energy carrier you must produce it and keep it "prisoner" and stable.

When you take it you generate heat, then you have to take it from A and bring it to B, the hydrogen turns back into water, or whatever its form was before. During the transfer it gave me energy. It would be such an amazing thing if the transfer wouldn't require so much energy. It's not that simple. We followed the project of an electrolyzer. We received funds from the Saving Bank of Modena, such a farsighted gesture. We received funds also from RCM, a company producing cleaning machines, they also realized a hydrogen-powered sweeper and believed in us. They also funded an electrolyzer that worked together with eight photovoltaic panels of the German company Q CELLS, the high-performance panels for cars used in parking areas, which are not comparable to the panels used for solar cars. We built a mobile solar station with eight panels. We left it in the school yard and in two days the solar station produced around 1 m³ of hydrogen that I held in a metal hydride cylinder



because I was a bit afraid to work with pressure ranges of 300, 400 or 500 bar, even if now the law allows it, but still I was afraid to work with these high pressure ranges. Through the metal hydride cylinder I could extract hydrogen with a bicycle pump used to inflate bicycle tires. So, I excluded a serious danger. Hydrogen is inflammable but it is less dangerous than LPG gas. If you check the tests of Mirai and Hyundai's cars, I mean standard cars in the market, they all had five stars in the crash test rating. LPG gas and fuel are more dangerous than hydrogen.

Barbara Grazzini (InEuropa srl): I'd like to remark this because there's a preconception that hydrogen is a danger.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): At first also electric cars and Tesla. When a Tesla vehicle caught fire in the USA, the newspapers around the world wrote that Tesla vehicles caught fire. Remember that when Paris saw the first Ford vehicle, back in the 1930s, the city was packed with horses and carriages. When Ford electric cars with lead-acid batteries started to replace carriages, when the first heat engines and carriages with a heat engine appeared in Paris, the newspapers wrote "This engine will never be popular, it's noisy, it frightens horses and catches fire". My grandparents bought petrol in pharmacies, they were very careful when they went to the chemist's and used glass containers.

Barbara Grazzini (InEuropa srl): Exactly.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): Also think about fuel injection systems. If you listen to the radio, there are many cars and vehicles catching fire on Italian roads and motorways while their injection systems have nebulizing pressures to save energy and to reduce pollution.

Barbara Grazzini (InEuropa srl): Absolutely.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): Fuel injection systems have been an accomplishment, but petrol hasn't become our friend. We drive vehicles filled with petrol. It's not that different from driving vehicles with hydrogen at 700 bars.

Barbara Grazzini (InEuropa srl): Since we're addressing school which might not...

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): I haven't replied to your question, I'll do that later.

Barbara Grazzini (InEuropa srl): I wanted to ask you this.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): What happened to my plant at school?

Barbara Grazzini (InEuropa srl): Yes, I want to know that because we're curious, I've mentioned it and you have to explain it to us. Tell us about that, then I'll ask you something else.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): For teaching we bought models, which are on the market and are very interesting, to do some experiments every school can follow. A small solar system and a small fuel cell powering a fan.

We built this lab equipment placed in a 2 m² laboratory at an affordable price for any school having a laboratory or asking for small external funding. Our beloved friend Ferrari gave us funding, I won't deny that. In Maranello, the whole territory helped us.



Obviously, the territory and funding are not enough, you need to throw away books that explain heat engines properly but are actually useless, create a suitable booklet and an innovative study plan diverging from the academic program. Our activity was, if you want, partially illegal. We always put safety first because I have students. We had some accidents but nothing serious. We played with cars, we participated in competitions, we did many things, we were in Australia and in the USA for many competitions. The vehicle might have been illegal in the academic program, but it wasn't illegal in terms of safety. Unfortunately, the firefighters closed my hydrogen unit. That wasn't the first time.

Barbara Grazzini (InEuropa srl): What year was it?

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): What?

Barbara Grazzini (InEuropa srl): When did it happen?

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): In 2011.

Barbara Grazzini (InEuropa srl): Not that far.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): Ten years ago. From ten to fifteen years ago. I think I started to do experiments on vehicles fifteen years ago. We built a small vehicle, which was in scale with the lab model and had 1 kW power. We bought the equipment and we built it.

We had a student who raced in Maranello, it was actually in Fiorano, with a vehicle weighing 60 kilos called "Fuel Buster". We still have it at school, it has a small fuel cell with 1 kW theoretical output and 400 W effective output. We drove for about forty kilometers with a solar panel on the car top, but we seldom used it. We drove for forty kilometers on the racetrack in Fiorano with this hydrogen car. We kept it in the dark, nobody knew about it because it was illegal.

Barbara Grazzini (InEuropa srl): You couldn't do that.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): Legal provisions on hydrogen, which still needs to be improved, were implemented two years ago in Italy. Germany had already implemented it and in Italy we still discuss it, exceptions made for 600 and 700 bar vehicles. The good news is that it's coming, but you can see my face. I don't want to talk about politics, but an old politician said that Italian politics was all about future elections, instead of future generations. It's still valid. The newspaper Il Sole 24 Ore wrote that Italy invested 2 billion euros in hydrogen and 5 or 6 billion euros in Fiat Chrysler Automobiles N.V. while on the same day Germany invested 7 billion euros in hydrogen. That happened on the very same day.

Barbara Grazzini (InEuropa srl): I see what you mean.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): For developing hydrogen technologies. I won't add more.

Barbara Grazzini (InEuropa srl): Getting back to education, let's stop with this for now because your message is clear. We have schools of every stage, from children to teenagers, such as your students, who are about to get their driving license, while primary and secondary school students obviously are not. What would you suggest doing? Can you tell us some experiments since children today are...

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): We started with projects for secondary schools, we did things for primary and secondary schools. My students made a

solar cooker. We also joined the Milan exhibition. We cooked food with this solar cooker, which we had made out of shoe boxes. I think and believe we should use renewable energies, solar energy above everything, to produce hydrogen.

We are very lucky. In Italy solar energy is now an important renewable resource, we have recovered lost ground over the years. It's not only a critic, regulations and incentives are good. We have a good percentage of solar power, together with hydropower. This vector is changeable, it might be sunny when the factories are closed, while when they're opened it may rain.

This variability really helps us because we can collect hydrogen. The best way to produce hydrogen is electrolysis. There are other methods, but this one is the safest and most used one. The electrolyzer converts electricity and, through a heat and chemical process, water is broken down into H₂ and oxygen, so you have hydrogen. At this point you collect hydrogen and you combine it again.

When you reuse it, its pressure must be high or it's useless. When you reuse it, it turns back once again into distilled water. We also have a heat process, which allows hydrogen technology to be used also in boilers since methane distribution can also be used for hydrogen distribution. This system can be very interesting.

So, primary schools can discover renewable resources with small experiments, which are also low budget, such as fuel cell examples, how a fuel cell works, if it collects hydrogen and if it's electricity, the waste product is water. When hydrogen becomes water again, you get electricity, but also hot water which may serve different purposes.

You can do these experiments without building an electric car, starting from renewable resources and trying to understand their efficiency. Remember that if the energy input is 4, the hydrogen output obtained is 1. We're right back where we started because of its poor efficiency. If you don't produce it with renewable resources, it's better to leave hydrogen be. If you go on thinking that the electrolyzer works with coal, methane and gas, you'd better leave it be. If compressors use electricity produced by gas or coal powered power plants, you won't succeed. You must keep an eye on the energy supply chain.

Barbara Grazzini (InEuropa srl): To end this first interview, since we might do others because there's a lot to say and tell...

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): I'm old, I have a lot of experience.

Barbara Grazzini (InEuropa srl): I didn't mean that. I was talking about your experience.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): You can say that, I have a lot of experience.

Barbara Grazzini (InEuropa srl): I wanted to say two things. If a school would like to come to Maranello not to visit Ferrari, but your laboratory to see your prototypes, is that possible? We didn't talk about that...

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): That's an obvious question. We continuously have visitors. I've talked about financial resources, but we haven't always had them, we worked with nothing at first. Now we also have a good partnership with solar cars, we have very interesting things, visiting Ferrari is way harder because they've lots of visitors. You can always visit the Ferrari Museum honoring heat engines and tradition, which count more than 200,000 visitors per year.

We're now building some Celerifero prototypes for light urban mobility with bikes and cargo bikes to clean up and bring this experience in everyday life and apply these technologies. The city of Spilamberto was at the forefront in this field, people from Maranello were pioneers and really



pushed to make this happen. We'll get a hydrogen fueling station along the motorway A22 and hydrogen will also be used for domestic purposes. A company from Rovereto makes boilers for apartment buildings, there are schools and mountain huts fully powered by hydrogen.

Barbara Grazzini (InEuropa srl): People coming here in the "Motor Valley" visit Ferrari.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): There are many things to do on heat engine vehicles that might help to reduce its weight, the number of people and create city cars. Hydrogen won't solve the problem of "derived vehicles". Toyota Mirai, which is an amazing hydrogen car, still weights 1,500 kilos.

Hydrogen must be implemented so that these huge battery packs can be reduced. Luckily, they cannot be used in means of transport, buses, lorries, so hydrogen is perfect for these purposes because nobody will ever make an electric lorry since its weight would be too heavy. The same concept could be applied to cars. If you reduce the weight of the accumulator and add a hydrogen tank, you can build a hydrogen and electrochemical hybrid.

The vehicle and the engine are still electric, but they can become heat and electric powered. If the hybrid accumulator is electric and electrochemical and the vehicle is hydrogen powered with tanks, you have a vehicle charging faster and having an amazing autonomy. The acceleration rate is given by the accumulator. We reduce the battery pack. I'm very worried about these battery packs. There isn't a proper disposal facility.

You have to think that hydrogen is an energy carrier and the car is a carrier, since it transports energy.

If you have a hydrogen car with a 4 m² solar panel on its top, with high performance cells, you don't need anything else, you move energy. When I drive home or to work, I perform a "Vehicle to Grid", "Vehicle to Home" or "Vehicle to Building" activity. I move energy where it's needed at that moment. Accumulation diminishes, which is always complicated.

In 1995 I drove from my home, 7 km away from Maranello, with Oxiana and ten solar panels produced by an Italian company. I drove from home to school and back with this solar vehicle and I never plugged it in at school. I never stole energy from the school. I only used solar panels in 1995. We're in 2020. That's it.

Barbara Grazzini (InEuropa srl): That's the end, but we'll keep in touch. Thank you because you gave us many ideas and I hope that our viewers will be curious and will ask something. It's important to encourage the creation of school and student communities with girls and boys dealing with this subject in the real world. That's why we launched an International Contest with FCHgo to encourage innovation and thinking on the applications of these technologies.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): They're innovative and new since we don't produce them, they're just prototypes. They're not available on the market, there isn't a mass production.

Barbara Grazzini (InEuropa srl): We don't see them yet. Thank you, professor, see you next time.

Prof. Filippo Sala (Laboratorio Prototipi IIS A. Ferrari Maranello I.T.S Automotive): See you, bye.

Barbara Grazzini (InEuropa srl): Bye. Thank you.