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**Moderator questions in Bold**, Respondents in Regular text.

**KEY: Unable to decipher** = (inaudible + timecode), **Phonetic spelling** (ph) + timecode), **Missed word** = (mw + timecode), **Talking over each other** = (talking over each other + timecode).

Swagath Manohar: Hello. I'm Swagath. I'm a senior consultant with Frost and Sullivan in the energy environment domain and in this webinar, I'm gonna talk about the hydrogen economy. So with the increasing conscience towards the climate change and (inaudible 00.18) increasing carbon emissions, so many countries are actually grappling for solutions for how to control the carbon emissions and also how to reach carbon neutrality. And so many countries have identified these different measures as a, a strong solutions toward the ways in which they can control their carbon emissions and achieve carbon neutrality and also the decarbonise their different polluting sectors as well. So none of these are new. So we have all seen these solutions, you know, like, in various parts of our (inaudible 00.54) life. So in terms of the first one, so rise of renewables. So in recent years, there have been a lot of investments across the increasing renewable capacity as well as many countries have realised that renewables is the way to go forward in order to cut down their reliance on fossil fuels as well as to ensure the energy security as well. And hydrogen economy. So hydrogen economy is now not something new but it has been the talk for almost three to four decades now and until recently, where not many countries have realised it's real potential and it's a perfect (ph 01.30) time to actually invest in the hydrogen economy in order to actually reach our climate goals.

And direct electrification and renewable heat, and this is also one of the major solution in which not many countries are actually looking to replace their fossil fuel controlled industries where-, and replace the fossil fuels systems with electrical ones across in major industry or major polluting industries like steel, cement, and also other chemicals. And emission management is a new thing, and, and also-, this is also one of their (inaudible 02.03), you know, like, in which countries can actually implement to reduce their carbon emissions and as well as also, you know, can trade their emissions as well. So we have something called carbon trading, carbon pricing and everything. So this all comes under the emissions management. And energy efficiency, so this is also one of the most important thing to which many countries can actually reduce their carbon emission. So it's a practice to which, you know, like, you implement energy emission practices, like circular economics, sustainable practices, to which you can actually cut down a lot of emission and as well as in all these circular (inaudible 02.39) -based materials they use a lot of waste and everything to which we can actually lead towards a sustainable future. So together, so all these solutions combined as a whole, will enable us to reach our climate goals and it's very important that in all, like, a-, every country actually focuses on all, all these pillars and then ensures that they take sufficient steps to actually implement these measures and focus towards cutting down the emission from across the different business sectors.

And I'll come into the key topic of today, a hydrogen economy. So in recent years, not, like, (inaudible 03.20)-, there have-, there have been a lot of interest across many governments and also across many institutions. So they have come up with a-, like, many countries have come up with these hydrogen strategies in which they wanna (ph 03.32) be implement and also, you know, they want to build a lot of new hydrogen infrastructure. They want to use hydrogen across much of their business, across-, including the mobility and that, sort of, industries. And as well as they want to, you know, like, store the hydrogen to which you can use it, in terms of demand, everything. So there have been a lot of hype and as well as, you know, like, a recognition of hydrogen mass. One of the green (ph 03.56) (inaudible 03.57) in which hydrogen can cut down a lot of the emissions and hydrogen can enable us to reach a carbon neutral-, a carbon neutral values-, value. So why all this over hydrogen? So why not over the-, any other elementary chemical? So the main difference that, you know, like, hydrogen's available everywhere and so it can be produced in different variety of ways and it can be also not stored and transported and it can be turned into different forms to which, you know, you can find its applications across different business segments. So for example, the hydrogen produced from renewables that's got green hydrogen, so it can find its application across the industries like steel, in which you can cut down a lot of carbon emissions from the steel industry and then combine with nitrogen.

So it is-, it is able to-, we are able to get green ammonia, which is-, can be used as a fuel for marine ships which would actually-, you can turn a lot of emission to the marine sector. So hydrogen, when combined with the carbon, which is captured and stored, so we can order it in different forms, like, terms of with methane, diesel, methanol. So it can be used across a variety of chemical industries as well as it can be used as a marine fuel as well as aviation fuel. So this ability of hydrogen, no, it can be converted into different forms and also it can be used as a feedstock or also a direct source of power generation, makes it a much suitable element for, no, as it can be used to release the emissions and which can be used to decarbonise our-, sorry, variety of business segments. So hydrogen spectrum. So, like I mentioned earlier, hydrogen comes-, we are based on the type of production. So it comes in different colours. So, like, it's more natural form, it's called gold hydrogen. So where hydrogen occurs in natural form in geological formation in caves and we have black hydrogen, so which is the hydrogen produced from coal gasification. And then we have grey hydrogen, which is formed through the natural gas and then we have most common, green hydrogen, which is produced from renewable energies. Also, with increasing the-, with carbon capture and storage and-, so we have blue hydrogen which is-, so you produce the same way in which you produce from natural gas but the carbon they also released is not (audio distorts 06.33) and also imperially (ph 06.35) placed for different purposes. So that's blue hydrogen.

And in recent years, there are also much emphasis on new technology called lithium pyrolysis. So in which the natural gas burn (ph 06.46) is converted into hydrogen but instead of carbon dioxide, the whole carbon dioxide is converted into carbon black, which again, finds its application across different industries as well, like for producing tyres as well as for (inaudible 07.01) making pigments. So this hydrogen is now-, it becomes a (inaudible 07.06) hydrogen and also, beside this, we also have hydrogen produced from algae (ph 07.11), from biomass and that's what it's even we have hydrogen produced from solar activity (ph 07.15) and as well as from nuclear as well. So there-, there's a huge spectrum of hydrogen available to us and the cost economics for each of these different process is different from each

other and, right now, hydrogen produced from natural gas is one of the most cheapest way in which-, in the market but, like, when you go down, like, ten to fifteen years from now, the green hydrogen will also definitely likely to catch up and become a, a rich cost parity (ph 07.44) with the grey hydrogen. Looking at the value chain. So in terms of the value chain, so we have three different types where we have the-, a production of hydrogen and we have the storage and transport of hydrogen and then we have a (inaudible 08.03) of hydrogen. And each of these elements have huge challenges in terms of-, so right now, green hydrogen is produced from renewables but as we go down the future, the amount of hydrogen required to decarbonise any industry require a dedicated or huge amounts of renewable energy capacity.

So that's going to be one of the challenges in the next ten to fifteen years, where, you know, like, we people who-, many countries would actually require the, the French they are dedicated hydrogen renewable energy capacity to produce hydrogen. So that's going to be one of the challenges because, right now, much of the renewable energy capacity, you can-, is only used for in order to balancing their demand and supply as well as the energy security. But as the demand for hydrogen increases, they would need a dedicated hydrogen and that's gonna be one of the major challenges. The next major challenge for hydrogen is that the absence of no dedicated storage in-, and no transport infrastructures. So right now, one of the main ways in which, you know, you can transport hydrogen is through convert the green hydrogen into green ammonia, which can be transported in different (ph 09.15) distances via ships. Americans are actually in the national charities (ph 09.20) have put forward a plan of converting hydrogen into green ammonia and then transporting it to larger distances. So initially, all the transport will go up into green ammonia but as the technology processes-, so there might be different ways in which, you know, hydrogen can be transported as well as store. And another important technology where many companies are looking at is that-, so instead of ammonia. So this hydrogen can now also be blended into the (inaudible 09.49) existing gas grids and which can be stored, or also transported, over the long distances.

But many countries have a gas grid in different states and amount of hydrogen which any gas, you know, convert becomes a form, the state of the gas grid as well. And many countries are actually exploring this, in which how much percentage of hydrogen that can be in order to turn into this gas grid-, gas grids for safe storage and transport. But again, it's a challenge in which many countries needs to solve. And then in terms of utilisation. So many countries have focused initial-, in the initial stages, many countries have initially focused only on (inaudible 10.29) of hydrogen across the mobility as well as the industry segments, so that's where bulk of other high emissions, carbon emissions, come from. So in the next ten-, five to ten years, so in terms of utilisation, so bulk of the carbon-, sorry, bulk of the hydrogen applications will be brought (ph 10.48) for the mobility and industry segments. So in terms of key countries which are actually have their own hydrogen developments, so, so looking at the, the key countries. So US is one of the key countries because the country has huge, tremendous renewable energy potentials and in terms of technology, so it has a lot of industries, a wide variety of industries and start-ups which are actually more focused on hydrogen technologies and they're actively collaborating with each other (ph 11.22) to produce different-, or to actually, to work on the different hydrogen technologies. And also, the US is actually planning to become one of the key exporter as well, so-, and it's already now with-, in talks with, like, Asian countries as well as Latin American countries where it could export the hydrogen.

And in terms of which hydrogen. So US, US is actually looking at more to green and blue because of the carbon capture and carbon capture (inaudible 11.55) is already commercial at certain parts of the US and there are a lot of pilots for this going on, targeting production of blue hydrogen, across the different states. And coming to Latin America. So the whole region has a huge potential for renewable energies and this region has a lot of potential to generate-, to produce green hydrogen. And Chile is one of those countries with a lot of wind potential and the country is actually in the hydrogen strategies. So actually come up with a plan that, that they want to become a leading exporter in the-, for green hydrogen and they also want to develop the cheapest green hydrogen market as well. So, Northern Africa, it's still very-, at least it is for Northern Africa, but this region has a lot of potential for solar and as well as for the wind. And once the governments are, like-, the Egypt or Morocco, they have the propeller (ph 12.53) regulated (ph 12.55) thermals (ph 12.55) to support the production of hydrogen. So this region could actually become a gold field for green hydrogen, where the green hydrogen can be produced and then they can transport it to all the different parts of Europe via available pipelines. And Germany's already in talks with establishing a pipelines all the way from Germany to the Northern Africa, where the green hydrogen produced from this region can be transported to the Europe for now (ph 13.23) meeting its energy demands.

Again, Gulf region, we're including the (inaudible 13.30). So they have come up with a lot of ambitious plans to establish a huge electrolyser capacity and their key focus is, is on new and (inaudible 13.42) itself and given their technology, even their (inaudible 13.47), so-, and also, you know, in terms of technology as well. So there are a lot of projects that are likely to come up in this region and this region is likely to become one of the bigger exporters. And similarly, China. So China is, is a huge market for hydrogen. So China already uses bulk of-, almost 40 percentage of the global hydrogen is used in China and its, its, its plan is to, one, become one of the leading leaders in this fields as, as well as in the storage market. And the China is actually, right now, developing its strategy for hydrogen and it wants to, you know, make use of its huge renewable capacity to become a leading market across the greener, like, new hydrogen. So in terms of the potential role of the key countries in the future, so, like, I mentioned about Chile. So Chile has been-, because of its huge wind energy potential and as well as-, and as well as the cost of electrolysers, so it can become one of the key countries to produce green hydrogen and also become one of the key exporters of green hydrogen. And Australia. So Australia, right now, is one of the happening markets for hydrogen where it has already established itself as a huge market and it has already, you know, in talks with Japan and Korea for-, what do they call?

For transporting hydrogen in form of ammonia to these two countries and there are a lot of pilot projects. There a lot of investments that are happening across Australia and, and in, in the next five years, there a lot of-, the bulk of the happenings or bulk of the developments that happen in sector (ph 15.34) across the world. This is going to happen in Australia and, and this country's going to become one of the leading exporters as well. So in terms of the Europe ingredients (ph 15.45), so France, Netherlands, Germany, UK. So they will all come up with their own hydrogen strategies and they're actively pushing forward with a lot of pilot projects available and as well as a lot of investments to actually increase their

production of green hydrogen and as well as other forms of hydrogen as well. Japan and Korea, so it's one of the big emitters. So due to lack of the space as well as the lack of sufficient renewable energy capacities, so they're actually going to be one of the biggest importers of hydrogen. And Japan and Korea, they're actually focused on becoming one of the leaders in fuel cells where the hydrogen will be used, and power generation is one of the areas where they want to use the fuel cells and the hydrogen for-, no, for balancing their supply, supply and demand. And this screen, this slide, we see about in all the key-, the developments across Europe. So the key takeaway message is that all are in the Europe, they are looking at actually 40GW of electrolyser capacity coming online by 2030 and there are actually investments given (ph 16.58) for 150 billion until 2030, which are actually many countries have planned.

And hydrogen is going to be a bigger market. Green hydrogen in particular is going to be a bigger market across this region. And in terms of key areas of support, so we have industries and transport. So much of the focus of all the different countries is when we are in this (inaudible 17.22). That's where bulk of the carbon emissions from Europe also comes from. So this is- this slide, we see a production forecast and-, so these are when you look at the hydrogen forecast available online. So many plans show that-, so due to the demand, so they are very high numbers and some of, also, it shows a very low demand as well. And we have come up with a low base and high scenario and, and we typically think that the base scenarios are more, like, a optimal one in which the-, in which the hydrogen demand is going to increase. So this shows across, you know, like, production of-, the production forecast and in terms of colours. So grey hydrogen's going to be dominant until about (ph 18.14) 2030 and, and order which you can (inaudible 18.18), we can see the direction in the grey hydrogen. And so with the carbon capture and storage technology becoming commercialised by 2025 and that's as well as the increasing renewable energy capacities. So we see that the blue hydrogen and green hydrogen taking over the grey hydrogen and also, we see a lot of, you know, like, many countries are now actually thinking about (inaudible 18.41) repairing their nuclear capacity. So in turn, they can focus-, or they can redirect their existing nuclear capacity to produce hydrogen as well.

So this hydrogen produced from-, in terms of methane biologies and also hydrogen, nuclear, (inaudible 19.00) one of the ways in which you can produce more hydrogen and meet the hydrogen demand as well. So other forms of hydrogen's also expected to take over after post-2030 and so we expect to see, you know, a lot of interesting things. A variety of different production methods reaching across parity with the grey hydrogen and taking all the production (inaudible 19.23). In terms of the hydrogen market, the ecosystem, the entire market is right now. You know, like, it's a very much a happening space where there a lot of companies, a lot of start-ups, there a lot of SMEs, you know, available in this space across the different huge variety of hydrogen. Like, we have a, a lot of companies across electrolyser as electrolyser manufacturers. We have a lot of infrastructure developers for a lot of companies focused on storage and we expect to see this market becoming more and more active in the coming years, and we also expect to see a lot of mergers and acquisitions happen across this market as well. So coming to the road map for hydrogen, so actually, the key thing (inaudible 20.15), you know, like, so hydrogen economy cannot we know, like, just achieve in a matter of ten years, so it will take at least ten to fifteen years for us now before as-, to establish a proper set of groundwork and regulatory frameworks on which, you know, we can develop the hydrogen economy. So the next five to ten years will be actually-, will be basically here

about development of proper regular frameworks and development of new pilot and demonstration projects.

And, and post-2030, so we can see a lot of commercialisation happening and, and so that's the rollout of big electrolyser and renewable energy projects and post-2040, so we can see the-, you can see a (inaudible 20.57) scale electrolyser projects coming online. A lot of a unknown (ph 21.01) colours, a spectrum of colours of hydrogen, as well as coming up to actually start play (ph 21.07) the demand for a lot of hydrogen. So in terms of key growth opportunities. So we identified four main growth opportunities for hydrogen. So one is the power-to-hydrogen. So which is actually converting the hydrogen into different forms which can be used as a direct fuel as a feature across different industries and add to this, the important role of ammonia, so as a green energy carrier. So it can be used to-, in order to decarbonise the maritime and the aviation industry as well as used as a storage medium to transport the green hydrogen. And hydrogen itself as a energy storage medium and it can be used during peaks-, during peak demand. So that's also one of the growth opportunity for, for hydrogen And lastly, new development of infrastructures, maybe giving (inaudible 22.00), like hydrogen refuelling stations and hydrogen operation centres and everything. So that's going to be one of the growth opportunities in the coming years as well. So power-to-X technologies. So the key-, this is actually a, a way in which, you know, like, the hydrogen can be converted into different forms. So we can convert it into a fuel which can be used for running the fuel cells.

It can be converted into a different chemical form which can be used across the chemical industry and, and, like, you know, material can be used across the chemical industries, or in glass industries or petrol chemical industries. Or it can be used as a direct fuel in the steel industry as well. So this-, the process of, you know, converting hydrogen into its different forms is, is called as power-to-X technologies and this is one of the key growth opportunities of hydrogen. And Denmark, in its hydrogen strategy, has identified this power-to-X technology as one of the key ways in which Denmark can achieve carbon neutrality. So when I talked about ammonia. So earlier, ammonia was used-, ammonia is for fertilisers and the (inaudible 23.11) exchange in pharmaceuticals but in the coming years, when we have a huge renewable energy potential, so those renewable energy can be now transported to different parts of the world but can only do green ammonia. And also, this green ammonia can be used for electricity generations as a fuel for maritime and aviation, and as well as it can be stored and transported, like I mentioned earlier, and also across the key chemical industries as well. So in, in the next fifteen years, you know, like, when green ammonia becomes a new commodity for countries in order to be either used as a decarbonising agent or it can be used as a transport agent as well. And I already talked about blending in hydrogen. So this, again, one of the key growth opportunities to which hydrogen can be either stored and transported or it can all be used, not for supplying heat, supplying for industries where in which carbon emissions can be actually drastically cut down.

So coming to the key conclusions. So, so the focus of the, the decade, we know it will be for the countries to first establish proper centre for regulatory frameworks and also in terms of getting investments ready

for building of the infrastructure. So next important thing is the countries should expand their R&D so that they can build on the (inaudible 24.33) the production as well as in storage and transport of hydrogen. And the third important thing is we need to actually ramp up the electrolyser capacity to actually bring down the costs associated with the production of hydrogen from electrolysers. And lastly, so instead of green hydrogen, so every country also should focus on, like, other, kind of, colours of hydrogen, like turquoise as well as pink hydrogen. That is really nuclear, no, which can be also used to satisfy the demand for hydrogen in the coming years. So it's going to be really interesting years for hydrogen and, and we believe that hydrogen economy will be the answer, you know, in order to achieve our climate goals. Thank you.

**Moderator: Okay. Thanks very much, Swagath. We now have-, we've, we've some time set aside for questions and answers. My name's Barry Faloon. I'll be putting any questions that you might have to Swagath. Swagath, can you hear us okay?**

Swagath Manohar: Yeah, I can hear you, Barry. Can you hear me?

**Moderator: Perfect. Yes, we can hear you loud-, I know Swagath was having some broadband issues towards the end there, so we're gonna keep his, his camera off at the minute but just a reminder, if you do have any questions, just pop them into the chat. I see we've well over 100 people online at the minute, so the, the, the numbers have been great and, and if you have any questions that, that you'd like me to put to Swagath, just put it into the chat and we'll try to get round as many of them as possible. And we have had a couple of questions in so far. So the first one, we'll get-, we'll get straight in is, 'Do you think green hydrogen is the way forward towards our transition towards decarbonisation?'**

Swagath Manohar: Definitely. Green hydrogen is one of the ways, you know, it will be-, we can actually achieve decarbonisation. So the other ways are, you know, like, besides hydrogen (inaudible 26.28), renewables in the energy mix. We have hydrogen, you know, like, it can be used as a green fuel across the different business segments and then in terms, we have energy efficiency measures and also other forms of energy. So hydrogen is not the only solution, you know, in, in, in our journey towards decarbonisation but it is definitely one of the ways for which it can activate our transition towards decarbonisation.

**Moderator: So would you say it's not the only solution but it will-, it'll fit within, within the overall mix? Next question, and again, it's someone who's just picked up on the-, one of your last slides which says that, 'The government support is, is required and it's, it's vital. Are you seeing that there's a, a, a will or a, a recognition from government that that support is vital?'**

Swagath Manohar: Definitely and, I mean, because, you know, like, because right now, the production part and as well as the storage and transportation part for the hydrogen is (inaudible 27.33) and if we need

to increase production of green hydrogen, so we need to actually reduce the cost associated with the production and the storage part. And that's where the role of government pretty much essential, you know. We need incentives, we need support mechanisms, to actually finance the electrolyser plans and also increase the scale of-, for these electrolyser plans and also bring down any other costs associated with the hydrogen there. So we need definitely a lot of help from the hydrogen (inaudible 28.05). So from the government (inaudible 28.08), yes.

**Moderator: Great. So questions coming in thick and fast now and just to, to-, couple of you have asked about copies of the recording, etc., we-, we'll be uploading this on to investni.com in, in the next day or two, so just keep an eye on your emails we'll send you out. Questions come in for, I guess, on the Europe map which was your slide nine. There's no comment on the potential of Ireland for a renewable hydrogen generation and someone's just asked have you any thoughts on, on Ireland's position?**

Swagath Manohar: Yes, sorry about that. So yeah, definitely there is-, there's a lot of-, I mean, we see a lot of hydrogen activities going on in the Ireland. And Ireland is one of the countries, you know, there's a lot of potential for offshore and we see a lot of, you know, hydrogen production activities connecting the offshore and the, the hydrogen production where the, the electrolyser plants maybe do it close to those offshore farms as well.

**Moderator: And question which was, was very specific to, to Northern Ireland and, and I'm not sure if, if you know the answer to this but if not, we can follow up later but, 'Do you know who-, who's working on hydrogen specifically in Northern Ireland and, and how much hydrogen's being produced in Northern Ireland?'**

Swagath Manohar: I'm, I'm sorry. I mean, I don't have a specific number to that.

**Moderator: Yeah.**

Swagath Manohar: I'm sorry, my (inaudible 29.30), you know, like, I mean, I might be able to get the answer though, so-,

**Moderator: That's okay. So just on the summary slides, why only green and turquoise as the future of hydrogen? Does blue hydrogen play a role to move away from fossil fuel-based energy?**

Swagath Manohar: Yeah, definitely, blue hydrogen. Definitely, that's a, a key role there but our main goal is actually to reduce the carbon emissions and in terms of turquoise and any other forms of hydrogen, so there is no actually carbon emissions involved. So green hydrogen definitely will help us in our, our



transition towards decarbonisation but once we reach a point there, you know, like, where we actually really want to control the carbon emissions and that's where the turquoise and green hydrogen plays a major role.

**Moderator: Okay, (talking over each other 30.21).**

Swagath Manohar: And also, adding to that, so there's a lot of uncertainty, you know, right now in terms of the blue hydrogen and we already explained that, you know, the cost of the green hydrogen becoming less than the, the cost of the green hydrogen in the coming years. So yeah, I hope that answered your question.

**Moderator: Thanks very much, Swagath. So the next question it says, 'Is the current bottleneck in hydrogen production capacity or is it insufficient distribution network?'**

Swagath Manohar: I-, I'm, I'm sorry, could you please repeat that one?

**Moderator: Yes, so it's, it's question four. It says, 'Is the current bottleneck in hydrogen production a capacity issue or is it insufficient distribution?'**

Swagath Manohar: It's a capacity issue, definitely, because to satisfy a global demand for hydrogen, we need huge gigawatt scales of electrolyser plants but right now, it's a capacity issue which actually limits us in the production of green hydrogen.

**Moderator: Great, and the questions are coming in thick and fast, so I'll, I'll keep going with, with these. So the question is-, and again, I'm not a, a hydrogen expert, so hopefully, you can keep me right in this, Swagath. 'Is hydrogen a better option than bio-methane to replace natural gas in terms of GHG emissions?'**

Swagath Manohar: Definitely right now, looking at the cost of production for bio-methane, it's, it's pretty much on the higher side, and also looking at the scale, you know, with the-, with the production, so you need huge infrastructure and as well as huge place to produce bio-methane. So that's where, you know, right now, that's major constraint for bio-methane. But whereas, (inaudible 32.03) to hydrogen doesn't take up much space and also the cost associated with the production right now (inaudible 32.08) is much less and it can easily be converted into-, in the methane as well with carbon dioxide.

**Moderator: Great. Thanks very much. We do have time for a few more questions, so if you do have any, just pop them into the chat and, and we'll try our best to get round. So we still have some more**

to get through now. So this is a long question, Swagath. It says, 'Your slides showed the use of fuel cells supplied from hydrogen networks in a number of sectors, including residential, which would be supplied by distribution networks. Where hydrogen is to be used to balance differences between renewable electricity generation and demand, fuel cells used in combined heat and power solution here appears a very efficient-, or a very energy efficient solution, and would increase energy resilience.' Would you have a comment on that? That-, it's number seven in the-, in the chat just there, sorry, 'cause I know it is quite a, a, a long, detailed question but hopefully, I've, I've captured it.

Swagath Manohar: Yeah, I mean, definitely. So right now, it's too early for the hydrogen, you know, to be used in the combined heat and power solution for grid balancing activities. So I'm-, like you said, you know, like, so in the coming years, you know, the hydrogen, the production of hydrogen, will be mostly used for the grid balancing work and the use of fuel cells probably in the-, for the grid balancing or any other activities. Probably we can witness probably up to 25 to 30 years. So right now, the main application of hydrogen here is going to be produce the hydrogen whenever there's excess of power in terms of renewables, and then use it for the industrial activities, mainly to reduce the carbon emissions there.

**Moderator: Great. Thanks very much. A question-, a lot of what we were talking about was high-scale production and, and scaling up but someone's asked, is it sustainable to produce hydrogen on a small scale? For example, on a farm that has its own wind power, so very localised.**

Swagath Manohar: Definitely. It is-, it is the sustainable, so-, but looking at the cost of (inaudible 34.15) electrolyser plant, so still, you know, the cost needs to come down to make it more sustainable part and also, with respect to, you know, the-, with respect to the cost of production of hydrogen and the whole-, you know, because you need to produce hydrogen and then you need to consume it as well. So as long as you have electrolysis which is also pretty much close to the site of production, it is indeed a very sustainable way.

**Moderator: Okay, but, as you say, like all these things, it-, it's, it's, it's relying on, on cost coming down. What are the main alternatives to hydrogen in the terms-, in terms of decarbonisation? We're focusing on the hydrogen economy here but what would be considered the main alternatives to hydrogen?**

Swagath Manohar: Yes, like you mentioned in the past slide, so with-, for hydrogen, so we also need a lot of renewables, so we needed-, we need a lot of dedicated renewables to actually reduce the share of fossil fuels in our energy mix and also, we need a better alternate fuels, like, a nuclear could also be a good option. And also, we need something like energy efficiency measures and we need, like, a emissions management as well. So besides hydrogen, these are other factors also play a major role, you know, in our journey towards decarbonisation.

**Moderator: Great. Thanks very much. I'm not sure if you know the answer to this. Someone's just said, 'Can you recommend any books or any good reading material on, on the whole use and potential with hydrogen?' And don't worry if I've put you on the spot because we can-, we can follow up after the webinar with, with that question-, specific question.**

Swagath Manohar: I think you can-, you can actually look up on the IE Europe (ph 35.54) site. IA Indian Atomic Energy or Indian Energy Agency. So where there are a lot of, of good reading materials there for hydrogen there.

**Moderator: That's great. Thanks very much. A question just on, on sectors. 'Which sector or sectors are likely to adopt hydrogen?' And I suppose in the wider sense, and maybe more specifically in, in Northern Ireland and, and why do you think that will be?**

Swagath Manohar: Yeah, right now, the major focus for hydrogen, particularly the green hydrogen across Europe or even, even in Northern Ireland, would be mainly across the industries, you know, followed by, like, transportation. So that's where, you know, the major bulk of the emissions lie and also, that's where, you know, the, the storage and transportation is all-, the factor (inaudible 36.44) as well. So initially, the next ten to fifteen years, the bulk of for the green hydrogen focus will be mainly across the industries and then probably, you know, for transportation.

**Moderator: Great. Couple more questions still here if you still have time, Swagath. Thanks very much to everyone for, for such great engagement. We've, we've had lots of questions and, and some, some good discussions. Question says, 'What are your thoughts on governments developing and increasing nuclear power as opposed to hydrogen development?' Which I know you, you mentioned nuclear power is part of the overall mix.**

Swagath Manohar: So in nuclear power also could complement, you know, hydrogen. So besides renewables or nuclear power-, power from nuclear also could be used to produce hydrogen as well. And also-, and also, whenever, you know, like, when you are drastically cutting down your coal power plants and as well as other forms of other carbon-emitting power plants, so and also when you're going to start to layer renewables. So renewables, you know, they have their own intermittent nature, so whenever we have a dull climate also, there is going to be a shortage of power. So we need a complementary power in order to actually to support the renewables as well. So that's where the role of nuclear power plants is actually huge, very significant there. And I personally believe that, you know, like, usually, many European countries wanted to shut down the nuclear power plants but with these recent gas issues, you know, like, now the countries have decided to extend the lifetime of the nuclear power plants as well. And that's going to be, you know, one of the key factors as well, complimenting hydrogen as well as the renewables.

**Moderator: Yeah, yeah, complementing, as you say. Your, your slide, Swagath, where, where you looked at the map of the world and what regions are, are doing what, is, is there one particular region or area that you would say is leading the way in this?**

Swagath Manohar: Not many (ph 38.40) because we are still, you know, we've just started the race and, and actually, (inaudible 38.44) if they say a region that wins (ph 38.47) Europe, there's a lot of industry things going on across the Europe in terms of hydrogen production because, you know, a lot of countries are actually investing a lot in electrolyser plants. As well as, you know, looking at different ways in which they can reduce the cost of green hydrogen and also looking at the ways, you know, they can (inaudible 39.08) that hydrogen as well. So I would say Europe is a (inaudible 39.11) interesting region in terms of green hydrogen.

**Moderator: Great. That's all the questions that I have. That's all the questions that have been submitted. So, Swagath, thanks very much again for your very detailed presentation and also for, for taking time with the questions. We've had great engagement, as I say, with, with those that've, that've joined us, both in terms of number of people online but also in terms of the, the questions and the discussions that we've had. So I really appreciate everyone for joining us, everyone for taking part and, Swagath, thanks again. Just a reminder that if-, keep an eye on [investni.com/events](https://investni.com/events) for, for further events and webinars. Everything that Invest NI has, has planned is listed there and it-, it's a great starting point if you're-, if you're looking for more, more information or more of these events to attend. So, Swagath, unless you have anything else you'd like to add-,**

Swagath Manohar: No, nothing.

**Moderator: Perfect. That's great. Well, thanks again, and we'll see you all soon.**

Swagath Manohar: Thank you.

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