

ANNEXE C - ENTRETIEN AVEC M. FRESON, CAPITAINE DE FRSU

Introduction

L'entretien s'est déroulé en visioconférence via la plateforme Zoom, en tenant compte d'un décalage horaire de deux heures. L'intervenant se trouvant dans un fuseau horaire à +2h). Initialement prévu pour une durée d'une heure, l'échange s'est finalement prolongé sur deux heures. L'entretien s'est effectué en anglais et a été intégralement enregistré afin de permettre une analyse approfondie ultérieure.

En raison de restrictions imposées par le pays depuis lequel intervenait la personne, la connexion Internet était soumise à des contraintes techniques et de VPN. De ce fait, seule la communication audio était possible pour l'intervenant, tandis que la vidéo était activée uniquement de mon côté.

L'entretien a eu lieu alors que l'intervenant se trouvait à bord d'un navire FSRU, durant son embarquement. Il a aimablement accepté de participer à cette discussion pendant son temps de repos, le dimanche.

Le choix de Zoom s'est imposé comme la solution la plus adaptée, étant relativement peu restreinte par les autorités locales et gratuite d'usage. Cependant, la plateforme limitant chaque session à 40 minutes, une nouvelle session a dû être lancée, ce qui a occasionné quelques coupures durant l'enregistrement.

L'intervenant avait reçu, en amont de l'entretien, une liste de questions et des thématiques à aborder. Cette démarche visait à assurer la cohérence de l'échange et à maintenir une ligne directrice tout au long de la discussion. L'ensemble des questions transmises est présenté dans l'annexe D.

L'intervenant a donné son accord pour être cité directement, tout en précisant qu'il s'exprimait uniquement en son nom propre et non au nom de son employeur. À sa demande, toute mention explicite de sa société a été supprimée et remplacée par [company name].

La retranscription de l'entretien a été effectuée à l'aide d'un outil en ligne d'intelligence artificielle, « Transcribe » (lien : <https://transcribe.com/app>). La transcription générée automatiquement a ensuite fait l'objet d'une relecture attentive et d'une correction manuelle afin d'en garantir la fidélité et la qualité.

Plusieurs annotations ont été ajoutées à la transcription, notamment pour clarifier certains termes techniques. Des explications complémentaires figurent en bas de page sous forme de notes explicatives.

Retranscription de l'entretien

Interviewer : M Antoine BARTHELEMY référence [M].

Intervenant : M. Geert FRESON référence [Rx].

Date : 11 mai 2025 à 11:00 AM (Bruxelles LT), Durée : 1h41 min.

En Visioconférence entre Anvers (temps local Bruxelles UTC+2) et position de l'intervenant (UTC +4).

[Start the interview]

[M]: Okay, so before we start, is it a problem for you if I mention your name in the thesis and the annex? Or you can also be anonymous. It's up to you.

[Rx]: I have no problem that you use my name.

[M]: Okay.

[Rx]: As I've worked for a variety of companies, I prefer not to be too specific on where I work right now and what my statements would be about. I prefer to have statements in my own name and not linked to the company I work for.

[M]: Okay. Statement name but not mention the company. Understood.

[M]: During the interview I will make some notes. Of course, just don't be surprised if I don't, since I'm not listening, but just taking notes just for the interview. So first I would like to thank you about to according to me this interview.

[M]: This is my research question: about conversion to LNG career into FSRU¹, is it a relevant solution for technical. From technical, economic and environmental prospective, and what is the challenge associated with their global deployment?

For the interview I contacted you, because you are captain of FSRU and you have probably a good experience of deployment and LNG career conversion. I will let you to introduce yourself.

[Rx]: Okay. So hello, I'm Geert Frison. I am 39 years old. I have finished the Maritime Academy in Antwerp.

[Rx]: Hence the sympathy for alumni. I finished it, I think in 2008. If I'm not, oh, it can be one year more or less. 2008, I finished the academy. I went sailing directly to gas carriers.

[Rx]: And then I got introduced to the wonderful world of FSRUs by that ship owner at the time. In 2014 I migrated to a cargo officer position on the FSRU Toscana, which was a daughter

¹ « FSRU » means Floating Storage Regasification Unit.

company, which was Sideways involved with the management there and put me there under delegation.

I stayed there for seven years, five years as a cargo officer, two years as a Master and then I migrated again to another company due to local regulations and fiscality. I migrated back to a fleet that I used to know which is now under management of [company name] and I have been here now for a little bit more than three years as a Master on FSRU. The suitability related to your thesis subject is that the FSRU Toscana was a converted FSRU built on top of the "donorship"² called Golar Frost.

[Rx]: I have to say Golar Frost first because they have released the new Golar Frost afterwards to confuse everybody on Google. Then the Originally Exmar LNG RVs³ now managed by [company name] are purpose built FSRUs or purpose built⁴ LNG RVs which came keel up into existence as an LNG RV.

As such, I think I can shine some operational light on both choices and challenges you would have with both versions of the same narrative. Personally, I believe both options are viable. It's mostly evaluating the parameters that matter.

[Rx]: Some of them matter, some of them not so much. Your questions are good questions, but I will apologize in advance. Some of them I'm going to park a little bit on the side because in my opinion they are in reality less relevant than very often described in the professional literature. There is a lot of literature that was written by people with very little hands on experience and as this is still a relatively new business, the first FSRU left the original shipyard I think in 2007 or eight. It's still a relatively new technology.

[Rx]: The lessons learned after 10 years of operation are only arriving now. So there is a lot of discussion going on that is rather theoretical and that is inspired by people who have a theoretical understanding but might not know statistical relevance of the observations. Rollover, for instance, is one of those. There is much more discussion in the world about rollover than that there is rollover. Let's just say it that way.

[Rx]: It happens. It exists. I've seen it. It is not that critical and as far as I know, I think there is two documented cases where it actually became a safety concern and in both cases the safety concern was very limited. So the whole world being in a permanent panic mode for all over I would say is a little bit disproportional to the underlying problem.

[M]: Okay.

[Rx]: However, there is things that can be done.

² « Donorship » refers to the vessel prior to its conversion into an FSRU.

³ « RV » means Regasification Vessel.

⁴ « Purpose build » means a FSRU directly build as new, no conversion.

[M]: Okay just to I don't want interrupt the interview, but we will focus on this topic during the interview because you are starting now to answer all the question. Just to clarify, but it's okay.

[M]: Okay, we can start. I would try to start it in order because you are giving many, many information at one time. So it's quite difficult to organize. But yes, okay, I understand.

[M]: We can start to try it in order. You already say rollover it's not really a relevant problem. We can talk about this later. Okay, so it's a good, good presentation, very clear.

[M]: We can start now with a critical question. What are the key criteria for selecting LNG carrier suitable for a conversion into a FSRU ?

[Rx]: I would personally, there is some choices that need to be made which are going to be philosophical. Do you want a most type storage system? Do you want, do you want a conventional membrane carrier as a conversion starter?

[Rx]: Then next question would be which generation of vessel you are looking at and mostly which size of vessel

[M]: Yes

[Rx]: and as far as size of vessel goes. That would again be very politically inspired. It's going to depend on your final client. What is your proposed or projected offtake of natural gas out of the unit. If you are going to be in the low range, you would not necessarily need a big storage unit.

[Rx]: Typically, I would always advocate go as big as you can afford, because adding storage facility later is basically impossible and having a little bit more costs you almost nothing on a day by day basis.

I have the impression on the market that the selection of LNG carriers for conversion is mostly inspired by carrier availability and price. Most of all the price.

Where we see that for conventional LNGs currently the first, let me call it the first generation of the second wave, which is the carriers made around the early 2000s, these are all in the 135, 140,000 cubes class. Those carriers are carrying an age, they are coming closer to their 25 or 30 years of existence, and they are failing at a lot of ecological requirements in terms of exhaust, in terms they are not so relevant in terms of boil off gas efficiency.

[Rx]: They come with a boil off rate of 0.15 rather than the 0.05 that is now customary on the new builds. So these older ships are economically much less interesting because obviously in a world, in a globalized, globalized world that upscales everything, bigger is the ship, better is the profit range.

And then a more modern ship which is typically bigger would also have better numbers by the kilogram, by the tone, by the whatever. So these ships, these 135 classes has been a little bit low on the current market and they are, let's say, up for grabs. They Are the cheap vessels right now to buy. Where they fail, I would say is tank size and efficiency of propulsion.

[Rx]: But the second part is not something you would worry about on an FSRU. So you are only looking at tank size now and you're getting it for a bargain price. Now the only question is, can you still run your FSRU on that smaller tank size? And that would depend on the project you have in mind. And definitely there is a lot of projects where this class of vessels still can have a second life.

[M]: Okay, [laugh] it's a complete answer and it also answers the next question also. So, you say that the big finally in operational way, the big key criteria will be the capacity, in fact. The worst, the biggest value we have the most economically, is it in fact.

[Rx]: That is correct.

[M]: So, what in case of the conversion, again, what is the main technical challenge according to your experience ?

[Rx]: So in terms of technical challenges, meaning the actual things to be changed, I would look at a few facilities. I think you touch on it later on. Nitrogen production, you'll need to upscale it a little bit. You will have to install a transfer system.

[M]: Yes.

[Rx]: Whether you work by flexible hose or by loading arm, you're going to need a system that your carrier doesn't have yet. Then you will most probably want to satisfy your country of operation with some ecological measures in terms of power production. You're going to install scrubbers or recirculation on your power production on your engine room. There is no choice for that. Almost.

[Rx]: Then you will have to add a seawater heating system and will have to add the Regas plant itself on top of that. You're going to have to adapt some of your vessel to high pressure layout.

[M]: Yes.

[Rx]: Meaning the conventional LNG carrier works with lines that go up to 10 bars, maybe 12 in some designs. And now you are going to install an entire plant that works at a rated pressure of 110, 125 bar.

[Rx]: That is an additional challenge. Also, in terms of safety management, it means that you're going to have a different kind of gas detection, a different kind of sensors and management systems and ESD systems. All that is going to have a need for upscaling.

Additionally, and more invasive, because what I mentioned so far is all built on top. Now more invasive into your LNG carrier is going to be that you may want. You may want to have additional means for boil off gas management.

[Rx]: I see it's a question later, so I'll not touch too much on it.

[M]: Yes.

[Rx]: But most of these upgrades are invasive and you may want to refurbish before you start your automation and your control systems. And that would be, and I'll come back to that in

the end as a conclusion, but it would be my main argument against converting is that you mix different generations of equipment.

Meaning if you say you have a donorship, let me talk out of my experience. If you have a donorship that was built in 2007 and it comes with an IAS⁵ with an automated control system, which is the computers and the boards and the barriers and the whole thing of electrical wires that controls every action on your ship, if that whole thing is in a generation of 2007, it's going to typically, let's say, and don't shoot me for these numbers, please, but let's say that it controls 5,000 data points. Valve, temperature sensor, pressure sensor, whatnot.

[Rx]: Now you convert this in 2012, 2013, there is less than a decade between, but computers have grown a lot. And your new elements, your loading arms, your regas plant, your adaptations to the funnel are going to add another 60,000 data points to your control system.

Now, your original control system does not have the processing power to actually work through that. As long as you stay saying, as long as you keep in converting mod, you are adding on top, you're building on top. And unfortunately, that means you build on a weak foundation.

[Rx]: Not weak as per the original donorship, but weak for what you want to do now. So what is something that I've seen go wrong and that very often goes wrong because the budgets are so high and people who handle budget typically don't understand why a new computer is important, especially a computer that would cost you four or five million dollars. And they'll say okay, but this is five million dollars for a new windows. You can work with the old windows, right?

[M]: [laugh].

[Rx]: And the operator in the field will not manage to explain why he needs the new one.

[Rx]: And then these 5 million dollars is very happily kept in the pocket of the owner because it's a lot of money. And unfortunately, I would say if there is one thing you should do when you re, you can build on any hull, you can convert and you can build new. And at the end of the day it's, it would compare to do you have second-hand hulls for sale and how long is the waiting time in a shipyard.

Because in your economical model, these would be the defining factors is availability of donorship and availability of new building spots and then a price comparison over the total. The one Achilles heel that I see is you should strip the donorship from all the automation, you can keep the piping, you can keep the valves, you can keep a lot.

[Rx]: But as far as automation goes, you should get the newest generation in while you're converting, so that your whole process in every facet is controlled by a single system built in a single system architecture and philosophy. Because how it was built in 2007, it's going to roughly be the same as 2012. But in the philosophies, you're going to see that certain things have changed. From a centralized triple hard drive configuration, you go now to triple hard

⁵ « IAS » means Integrated Automation System, it is a centralized system that controls all the ship's systems.

drive configuration in every control point, centralized, decentralized, all these kinds of little things. Do you want to communicate with glass fiber or with copper wire?

[Rx]: All these little things are going to extremely complicate your final product, which is now going to be a multi-generational Frankenstein that becomes very, very hard to work on. On a bad day. On a good day, they're awesome.

On a bad day, you need to go troubleshooting in three different languages at the same time. That's kind of what happens in reality.

[M]: Yes.

[Rx]: And that is a challenge that is very often a little bit underestimated technically. The rest of the technical parts, what you need, you get. You want a compressor; you buy a compressor. Ships are big and usually you can bolt on top almost everything you like.

[Rx]: Typical FSRU equipment is in volume not so immense, and even in weight, it's manageable. If it's too heavy for the nose of the ship, you either add some floatability with a, with a blister tank on the forward, or you just position it a little bit more midships. There is, it is actually in my opinion, relatively simple, but not, not cheap. Not cheap.

[M]: You raise the point that I never heard before and it's very interesting, the automatization in fact, because you need of course more CPU and computer processing.

[M]: That's the thing I didn't think about, but it's quite relevant, in fact. To resume what you say, we add new equipment, we need to interface this equipment to the system already exists on the ship and it's quite complicated and it's underestimated by the builder and for the conversion. It's quite important. Okay.

[Rx]: Good summary.

[M]: And I didn't check any documentation about that, so it's quite surprising, but indeed, just to mention, I worked before as informatician, as developer, so I changed my career, so I completely understand this kind of problem. So it's a good, good remark and a good thing and this kind of stuff, of course will increase a lot the cost.

[Rx]: Yes.

[Rx]: And usually this comes after all the decisions are made when the donorship is bought and it's lying the shipyard. And now you're going over budget on some things because some of the equipment you bought meanwhile got indexed. Inflation arrives and oh yes, but we forgot to tell you that there is like a 20% margin on this thing and obviously it's never less. So now you come in the final phase before commissioning and honestly everybody ran out of money and out of favors. And that's where we don't upgrade the informatics part.

[Rx]: And it's more than the computers and the software. It's all the barriers, it's all the communication buses, it's all the modules. It goes down. I did at some point I had the pleasure of changing the entire switchboard configuration of an FSRU to a newer system of automation offshore.

[Rx]: I will say the offshore part is a little bit tricky. As in if you don't come back, the lights will not go on. It's a little bit problematic, it's silly. But it was a very fascinating challenge. We were engineering it for years before.

[Rx]: I think the total project took two years, which was spray engineering decisions. Hazop has it the whole story. The final implementation was 10 days.

[Rx]: We managed, we got away with it. I'm not recommending it to anyone, but it is possible.

[Rx]: I can say from experience, you can, and that would be my main line in all the technical questions. Everything can be engineered.

[M]: Okay.

[Rx]: The question is how willing are you to walk the distance? How willing are you to pay the price? This is.

[Rx]: These are the main questions. It is possible, it has been done, not everything equally elegant, not everything equally efficient. But almost all of it has been done or is in operation in an area of the world. But there are hidden costs. And for instance, the conversion of control system systems is something that is always underestimated in an original price quotation because people are, let's say the suppliers are bidding against each other to get the order.

[Rx]: And last minute these orders, they can really run out of hand. Especially consider that most of the technicians are freelance and they work on a day rate. And now you run into complicated IT problems more than switching off and on and you know exactly what I'm saying.

[M]: Ah yes yes yes [laugh].

[Rx]: And, your project derails itself in terms of millions, if not tens of millions in a few days, in a few minutes even. Just by running into an issue that you must solve, and you don't know how. And you will solve it.

[Rx]: It's just time and money, which is the two things usually in business nobody wants to invest.

[M]: Of course, of course. According to what you say exactly with the automation system. But it will be a little bit linked with the next question because several systems already exist on board, for example to handle boil of gas, safety... And because we have to interface this system to the new system, we need to add. This system so can be reused during the conversion. But it will be also complicated because we need to interface these two systems.

[Rx]: Typically, yes, they there will be in terms of boil of gas, which is the most important interface that I can see. What is challenging is that it's going to dig. This is one that digs a little bit deeper on your existing ship. Because at the end of the day, and I'm assuming you know what a vapor header is,

[M]: Hum hum.

[Rx]: Almost everything related to boil of gas on a gas carrier travels through the vapor header at some point in its life, preferably twice. Meaning in the aft of the ship you're going to have your consumption to either boiler systems with a compressor room or to your reliquefaction plant.

[M]: Yes.

[Rx]: And typically forward you have your regas plant and somewhere in the middle you will have a minimum send out compressor or a condensation skid, or another extra means that you have. If you don't have boilers, you're going to have a GCU somewhere in the funnel. But you're going to have all over your ship, you will have this variety of equipment and all of them interface with the vapor header which also interfaces with your manifolds. In other words, by gas code, it is mandatory that all these ships are understood to listen to an ESD and emergency shutdown and they need to be reconfigured because an ESD is not run on a Windows level, it's run on a motherboard level.

[Rx]: ESD systems are hardwired, so you're going to have to rewire your barrier boards. I'm now digging into this because I see your background, so I'm going a little bit deeper that side. You're going to have to go on a barrier level to hardwire again your ESD system, including your new equipment and modifying your existing equipment. You may consider that you now want to handle a different composition of gas than you typically had. So you're going to have to change your boilers or your GCU settings for combustion.

[Rx]: You'll need to change the airflow. If and I come back to the environmental ideas. If you would put exhaust gas recirculation or just scrubbing on it, you may have to adjust your combustion rates in your boilers. If you work with a piston type dual fuel engine, your gas composition would change some elements on, on that injection. You're going to have a lot of parameters of your existing equipment that need to be re engineered.

[Rx]: It's not impossible, but it's, it's quite a bit. And it's a lot of small things where the main challenge is that your engineering team of your conversion needs to run through the process of in their mind, engineering what you already have. To actually understand the full process scope and, and the complexity of the underlying donorship. And that's also a risk. If you build it from the keel up, you have to imagine everything you have to, and you have to build it with compliance with existing codes and regulation in mind. If you go cutting into something existing, it's relatively easy to overlook, a piece of code or regulation that was there, that was well covered in the original.

[Rx]: You redesign it for your new use, but you're now in violation with the code. And that may or may not be code. And this is a, this is a problem in terms of compliance with law, but it might also be a problem in terms of complying with safety logics, with process safety and with your overall design quality. Because if you miss the point : "why there was a valve there ?", "why this pressure sensor has an interlock on that piece of equipment to start ?", if you would miss the underlying reason why and you just say yeah, this is something old, you know, blah, blah, bullshit, you would dismiss this element or you would know one reason, but you don't know two of them. Maybe there was two reasons to have it and you only evaluate one, you'll mitigate for the one, you'll ignore the second, and your final product is now going to be something that misses an essential clue in its design.

[Rx]: That's the main challenge of conversion and that's the main advantage of building from the keel up. But this is theory. As said, at the end of the day, money will decide. Time in the shipyards, donorship availability. It will never be about what is the better one. No taxi driver can choose his Ferrari, you know, at the end of the day and it's the same logic for us.

[M]: Okay, so you mentioned before that the rollover is not really a big issue, apparently. About the new building, because I, I check on my research about, because there is many, many publications about the rollover issue, especially for FSRU because we have different composition of LNG, but according to you, it's not really a problem. So there is not really a retrofit or an arrangement in case of conversion.

[Rx]: There is a possible retrofit. I had it on my Italian ship and I don't have it on these ones. And I am not worried. Let me just say it in such words. Things you could do, you could install, and this is purely monitoring, you could install temperature sensors all over the vertical range of your tank to have a better understanding of what's inside. Different composition comes with different temperatures because obviously its boiling point would be at a different set.

[Rx]: So, you would see, okay, I have minus 158 until 10 meters and then it suddenly jumps to minus 160. I have a layer of colder LNG on top. This would be something you could see by temperature sensors. It does nothing except inform you. It's purely informative. What you can do, is you can start pumping around your tank, meaning you start a pump, and you start mixing it by pumping it around.

[Rx]: As you agitate the liquid and you pump it around, it's going to mix, and your problem goes away. Now, two observations that I do have is one: there is no "sane" operator in the world who will load on a tank which is half full. You will always collect in one tank and load in all the others. Meaning you're going to eliminate the rollover effect purely by your operational practice. In reality, that would be one thing that we all do and which is why it's a non-existent problem.

[M]: Okay.

[Rx]: Second observation is that rollover is much worse in shore tanks because shore tanks have no ship motion and no machinery vibration. In other words, shore tanks are actually... the liquid is much more static inside. It is perfectly static liquid, unless you agitate it.

[M]: Okay.

[Rx]: The same liquid on a ship is being agitated already, naturally, in many ways. Has rollover. Has it happened on ships? Yes, it has.

[Rx]: I have not seen it in catastrophic ways. I have seen serious pressure rises in tanks. One of the typical mitigations on an FSRU would be to ask the class to allow a higher safety valve setting, at least during FSRU performance. Meaning, and this is not a secret, for instance, the ships that I am on now, we all have 70kpa safety valves instead of 25. But when we go sailing, we reduce back to 25.

[Rx]: A practice that has been well explained for LPG carriers already 40 years ago. That you had different safety valve settings for the loading process. The same logic is applied to some FSRUs, not all of them.

That would be a convenient way of handling a little spike in pressure that passes by. And then do not Forget that the worst that can happen is that if you would line up for a rollover situation and you would not manage to mitigate it.

[Rx]: Frankly speaking, the worst that happens is that once every five years you will open your safety valves, and you will lose a few hundred liters of LNG in gaseous form to the atmosphere. It is a greenhouse gas. I am not recommending it and I'm not saying that is not your perfect action.

[Rx]: But if you look at it from a safety management point of view, it might be statistically in the range of acceptable risk.

[M]: Okay.

[Rx]: And that's something that is a little bit underestimated based on the fact that there is more experience with rollover ashore, than on ships. And the people who design it for ships typically designed it for shore first.

[Rx]: So, there I would say on ships I consider it personally to be less of a concern. I am not saying it is not a concern. I just do believe that there are a few factors that semi automatically reduce it. Some of them operator based, some of them just vibration, shaking. If you go sailing with a ship, everything is sloshing around so everything mixes.

[M]: Yes.

[Rx]: I'm not saying it's impossible, just saying less likely. And a typical recirculation system in a tank, which basically means that you would have a filling line that doesn't go all the way to the bottom, but you put one filling line that ends in the top and you just run your pump on recirculation bottom to top would be basically enough. It's again, we are not talking of huge conversions for this.

[M]: Okay, all right, good, perfect answer. Maybe we have time for one last question because it remains six minutes.

[M]: Of course, I will start the reunion to just be sure and to avoid having a cut. The next question should be based on your experience and try to be short for this one. What is the average duration for conversion project to planning for commissioning ?

[Rx]: Uh [thinking].

[M]: In average of course.

[Rx]: Well, I think in. In up. Yes, in. The problem is that the one that I was on has like the world record of duration. So, I don't want to use that as a benchmark.

[Rx]: I would say realistically, the minute you're.... Let's speak from donorship arriving in the yard to finishing the conversion, that should typically take you between six and 15 months, depending on how much you're going to convert it and how much fancy you want to put on it. Then time delays are a possibility.

In terms of planning phase, in terms of engineering and local regulation and permits basically from local government to go and install your unit on site. I have no view. Typically, these things take five years, but there is instances where it was done in six months.

[Rx]: It's really. That is a very political question. And. And as an operator, it depends how much they want you there, I would say.

[M]: Okay All right. Okay. I will stop the recording and the meeting, and I will create a new one to continue.

[Rx]: Very well.

[restart Zoom interview]

[M]: Perfect. Okay [start interview again]

[M]: One another question which can be relevant about regasification because it's depending on local regulation. But the demand of gas is never on average you can have a high peak of demand. And how the FSLU can manage this?

[Rx]: Well, normally an FSRU is a very flexible unit in terms of ramping up and ramping down from zero capacity to full capacity. The beauty of it is that your plant, to keep your plant cold is relatively cheap. And at the end of the day, you are looking at a bunch of six or seven pumps to start in terms of process pumps and then you would have three to six more pumps for your heating water, and you need the power production to follow. Now, as you are building on top of an existing ship, power production is actually already designed to follow variable consumption demands. Think half ahead, full ahead, that stop, that slow stop engine, etc.

[Rx]: Your ship is made to deliver power on short notice and to actually stop delivering power on short notice as well. So, you talk about a unit that is already prefabricated to have power available as per and when you want. Meaning you will have fast starting turbo generators. You will have a steam system that is built to ramp up fast. Your whole system will follow. Typically, I would say you would need two hours from zero to full rate.

[Rx]: And that's on almost all of the units, which is in terms of gas demand that is fast. Consider that with a normal gas operator is still using the pipeline as a buffer, meaning he will ask you to come in when the pressure goes down, but he's still going to allow the full network to drop a little bit of pressure, and consume that gas while you come in. They're not going to wait for the network to be empty.

You'll just produce into the system and the whole system will take a bit more pressure and you just one of the elements that pushes into that system in a more direct chain where you would just produce straight to a facility you would need to synchronize very well with the facility ramping up.

[Rx]: How I see it in my experience or what I've seen over the world, Argentina, Kuwait, Boston, Abu Dhabi, Bangladesh, Italy... I've seen Rigas in a few locations and typically it's always the short side which is the limiting point. The FSRU is more flexible than the receiver typically.

[M]: Okay.

[Rx]: Obviously an FSRU entry point is also designed for an FSRU. So I may have a falsified opinion here, but what I've seen is that that is never a challenge. Not really.

[M]: Okay.

[Rx]: In terms of gas treatment, what you said, I imagine you mean adding mercaptan or leaning gas and reaching us.

[M]: Yes, Yes.

[Rx]: All is possible. You could have a mercaptan stenching plant on the ship. Some ships are equipped with it, some clients demand it. This is mostly for gas that goes to domestic consumers. It's a very small unit.

[Rx]: Spoken as an operator, I hate it because it stinks.

[M]: [laugh].

[Rx]: and if it drips on your hands, you're going to smell for weeks. It's, it's really. It's really a dirty product. On the other hand, in terms of volume, a stenching plant would be like 3 to 4 cubic meters. We are talking about nothing.

[Rx]: It's a very small thing to install, and you would just need a probe that injects it in your final send out at the right quantity. It's a very simple, a very simple piece of technology actually.

Sometimes the client will do this himself because he wants to keep total control over that and he would not allow seafarers to play with that. That depends a bit on safety regulations on the receiver side.

[Rx]: An FSRU typically does not control the network, and it means that the network controller is still responsible and in charge of the network and its quality. And at that point they might doubt the typical seafarer logics in terms of robustness and [laughing] safety mindset for something like a 2 million people city consuming gas in their furnaces. Because that's what we're talking about. We talk about the amounts of gas that, that feed multimillion population cities. You may want more than 30 seafarers including Chief cook to be in charge of the staging.

[Rx]: It's something that happens. It depends on the client, but we can easily provide the service. In terms of technology, it is relatively easy.

[M]: Ok.

[Rx]: It's not a big deal. Other modifications or possibilities, they exist.

[Rx]: The Toscana is probably the only FSRU in the world who actually has that equipment. You could inject nitrogen into your send out, to make the calorific value of the gas a little bit lower.

Advantage would be that you would be able to keep working within a calorific range of a network specification. With LNG that is actually, I don't like to say "substandard", but that has either aged or is of a composition that is borderline, and you wouldn't run out of that composition.

Aging of LNG would be something you might want to address in a rundown of FSRU advantages and disadvantages.

[Rx]: Main difference being, if you have an oil tanker and you park it somewhere for six months because you think the value of the product is going to be more in six months and it will compensate for your charter rate. Basically, your financial transaction stops there. It's a very simple concept and its speculation, but it might work. Now for LNG, the problem is if you park your LNG carrier for six months, six months later, thanks to boil off, you don't have LNG anymore. You have now a gas mixture that has relatively spoken, much more propane, much more ethane, much more everything else, and much less of the good stuff, meaning methane.

[Rx]: That's a challenge. That means that and it happens also shore operators very often at the end of the winter season in Europe and at the end of the summer in the Emirates, will try to get rid of overstock. They don't like to keep the overstock because they cannot keep it for the next season, because by the next season it will be so rich that it cannot be injected in the normal net anymore.

[M]: Ohhhhh Ok.

[Rx]: Now you could compensate that by leaning up, which means you're going to have that rich composition and you just add 5% nitrogen.

[Rx]: Pure nitrogen, you just pump it in, you push it through and the calorific value, which is at the end amount of fire per liter, is going to be less again because there is nitrogen inside now. Magic solution works very well. Very few FSRUs in the world have the possibility, but it's possible. You could do gas treatment by injecting nitrogen. It's a possibility.

[M]: Okay, so it's link also to the next question about autonomous of FSRU. If it can be put somewhere near to the shore and just connect to the network, the gas network. But you can also need nitrogen, of course, for the safety, but also to inject in the gas to reduce the calorific value if the gas is too rich.

[Rx]: In terms of being autonomous, I will speak for Europe here. What Europe would do if you cannot make it leaner is the European network is a very complicated network of nodes and they will mix in your gas with some lean gas and they will mix in the high pressure piping, at which point the final consumer would never have the problem that you might create if it would go directly to them.

[Rx]: It's a possibility. In Europe you can do that. I worked at some point in a very short pipeline system in Israel. There you could not, because you are basically the only producer in a pipe that runs directly to the consumer.

[Rx]: And then that option would not exist. This again comes down to project scope and original design. You'll build what you need. If you don't need a nitrogen factory, you're going to keep \$10 million in your pocket. It's, I mean, it's not cheap.

[Rx]: You could have it, if you need it. If you have another answer to the question, you could also just tell your buyers, don't buy LNG with a meeting number less than so and so. You could work around it in terms of being autonomous, I would say on principle. An FSRU is 100% autonomous until the delivery flange.

[M]: [laugh].

[Rx]: It is the ship, so it is autonomous. But of course we produce to a flange whether that is subsea through a buoy system or whether that is on an actual manifold. It still means you would have, you would need something on the other side of that manifold. You would need a piping network to be equipped probably with a series of ESD valves, maybe even some high integrity HIPPS⁶ valves. You would, they might have their own metering system.

[Rx]: We usually supply the custody metering system ourselves. But the client may want to verify with their own flow meters and chromatographs. At which point you duplicate, but you compare your numbers. This would all be up to the client. Technically for an FSRU, I would say : I need a flange.

[M]: Okay.

[Rx]: I'm ready give me a flange. And I need nothing except a bunker barge, food and on occasional crew change. It's kind of how we operate. We work as we get you the full factory, you get the full product, and we need nothing but auxiliaries like a little bit of bunker fuel, crew changes, some service boats and a gangway to get people in and out, or a service boat to do the same.

[Rx]: But in theory, you get a full terminal which is self-propelled, as you say correctly. There is a few which are not self-propelled, but typically they are. Because typically the contracts that are built for FSRUs are still considering giving the unit back to the operator at the end of the contract period.

At which point it is much more convenient to sail away than to get towed back somewhere. If you're going to have a unit which has a location for the next 20 years, to answer your question, absolutely no need to have a propeller.

[M]: Okay.

[Rx]: The only thing you might want to consider is that if you class it as a ship, you need to go to dry dock every five years.

[M]: Yes.

⁶ « HIPPS » means High Integrity Pressure Protection System. In case of FSRU, some equipment manage high pressure flow and need to be protected for safety.

[Rx]: if, if you manage to convince your classification society to be exempted, from the five yearly obligation. Well, I know it's a two and a half yearly obligation but let me call it a 5 yearly obligation out of my habit and experience. If you manage to get your class to agree to not go to dry dock or to the repair facility every five years, then the need for a propulsion system is even less.

[Rx]: That depends. Again, that's a question on how you set up your project. If you go to a spot for six months, you would definitely not want to tow your unit to that location because your towage cost will outweigh the profit you make. If you say this unit is going to be for 25 years offshore in Italy, 12 miles off the coast of Livorno, then you could very well sell your gas turbine and have more room for your seawater pumps. this is a very specific example.

[M]: So this is question 10. In fact the propulsion system can be an argument for the flexibility, but also it can be used, to not having any propulsion system depending of the time that the FSRU will be placed.

[Rx]: Yes, it would be, I would say both is possible. It's an operational analysis.

[Rx]: What do you need from your FSRU? And in terms of redundancy, you are singling up your option if you remove propulsion. You are obviously excluding an option, but you are also excluding a lot of maintenance. You don't have to have every year divers checking if your propeller is intact, if something chipped it. You don't have sealing systems between the seawater and the engine room that need to be maintained, or the oil needs to be changed.

[Rx]: If you really don't need it, you are eliminating a cost. But you are also eliminating opportunity to change your business model. That's how I would see it and that's a balance that you need a very specific project before you can say what is the right option.

[M]: Okay, one question also. You already mentioned the safety standards, but of course there is international ship regulation like solas, marpol, IGC code, etc.

[M]: But about the specific's standard for the FSRU and is it depending on the local regulation ?

[Rx]: That is correct. An FSRU still falls under the GAS⁷ code, which is a chapter in the solas and needs to be compliant entirely with the SOLAS as such, with the GAS code. So that would be your main, your main point to look for. Then in terms of all your extra equipment, you do find yourself in poorly documented margins of regulation.

[Rx]: And you would work for some of that, you would work to best practices and to industry standards. There is no FSRU code as such, and the few FSRUs in existence are so different in nature that it would be very hard. On the other hand, if you split them back to what makes it an FSRU, you are talking about loading arms. There is clear regulation on what cargo transfer system needs to comply to. You talk about high pressure pumps. It's just a pump that pumps at a high pressure.

⁷ « Gas code » refers to International Gas Code (IGC)

[Rx]: You talk about high pressure vaporizer. Okay, it's a shell and tube type vaporizer. It's an intermediate fluid vaporizer but at the end of the day you're still talking about a heat exchanger. And as such it still fits into a lot of the existing regulations. You will find that very often we go a little bit more in the chapter construction for engine rooms, when we look at compliance for SOLAS, because we as decis.

[Rx]: Because as deckees⁸, let me call us deckees, you and me, we both are. But as deckees, your FSRU equipment is going to be a little bit more technical in nature. And it's going to force you to be a little bit more compliant with the technical chapters in the SOLAS. Strictly for FSRU, there is no code.

Then, as you said correctly, your port state, wherever you operate it may impose specific design considerations. Mostly I see that related to everything environment, from temperature of seawater, inlets and outlets to what you do in your chimney and with your exhaust.

[Rx]: That's where port states are specific. They're specific for everything touching environment, touching design, it is mostly controlled by the class because the flag states are delegating this typically to the class as they understand that this is such specific an advanced technology, that they have no real access to an informed decision. Therefore, the class would make that decision. And in reality, you will not find financing without going to a serious class.

[Rx]: I mean there is classification societies which would be very convenient in terms of cheap design. But nobody would ever finance your \$200 million project, if you are going to cheap out on your class. That's going to be a reality of it. Typically, ships are not financed directly by their owner, there is always a construction. They are not bought and then just put on the shelf.

[Rx]: So you'd be forced to work through a class and the class is going to warrant the technical evaluation of all your new technology.

[M]: Okay. Right, next question. Because you already answered about the autonomous of the FSRU. For your perspective, it's relevant design to be as much as possible autonomous ?

[Rx]: Yes.

[M]: About Question 12, from your experience to what extent to do location and weather condition limit installation of an FSRU, is there usually enough flexibility to find a suitable site ?

[Rx]: Well, of course I've only been on actual sites. So obviously all of them were found or deemed suitable at some point. I do know that sometimes tracking a site is difficult. More so in Europe where there is a lot of not in my backyard NIMBY effect.

[Rx]: A lot of it. Everybody wants the good stuff, but nobody wants to see it happening.

[Rx]: If difficulties related specifically to a political element to it and that would be dependent on your geographic location. And it's purely political. Political public opinion so and so.

⁸ « deckees » is a nickname for deck officers.

[Rx]: Location and weather conditions.... [thinking] yeah, I would, I would like to restrict my answer here because this goes to a very sensitive topic in my own company.

[M]: Ok, ok

[Rx]: [thinking] Yeah, I'm sorry for that.

[M]: No, no it is ok.

[Rx]: Like this I can tell you with a beer, but not on a recording.

[Rx]: Yes, it is important there is limits that are too much. I would mostly look at it in terms of operational envelope for your STS⁹. What you will need to do to be able to. You still want the liquid to arrive, so you're going to have to do STS. That would be your real limitation.

[Rx]: The ship and it's mooring. Whether it's on a buoy or on a jetty, you will always manage to engineer a mooring for a ship that can withstand the 100-year storm. That is the typical phrasing is that you would design your system up to a 100-year storm. Meaning if you have a storm that happens statistically once every 100 years, you would need to abandon the location and find safety at sea and come back when the storm passes. And you do this once every 100 years.

[Rx]: So, everybody expects that you never do this in the lifetime of your project. That's kind of the logic. But you would be designed for that.

[Rx]: And I would say the design is fair enough and feasible enough. I've seen crazy weather in such situations and I've seen the vessel and all the equipment around it survive it with ease.

So definitely in terms of the FSRU in itself, I am not worried about limitations. I do see that if you would put an FSRU in for instance a tidal port with a high tide and you would at the same time expose it to extreme weather, let's say 'Monsoon'¹⁰, to give an example, you might create a site that is really, really aggressive and undesirable for STS operations because at that point you run into limits. One hull to survive alone, it just dances around. That's what ships do, they dance.

[Rx]: And it's all fine. And most seafarers even like it. At least I do. But two ships moored 3 to 5 meters away from each other Both of them dancing, both of them 45 to 50 meters wide. Then both above and below your fender line, you start to have a lot of possible kissing points.

[Rx]: And that would be something that you should also mitigate when you look at weather. So I would say weather is not a limitation for your regasification process, but it might really work against you in terms of STS. And then depending how much cargo, how much volume you want to push per annum (year) and how big is your storage facility, that will create you an

⁹ « STS » refers to ship-to-ship transfert, when we transfer cargo ship by ship.

¹⁰ « Moosoon » refers to the season of heavy rain during the summer in hot Asian countries (Mousson en français)

operational margin that might be smaller than you prefer. Once again, in most areas in the world, this is not a real challenge.

[M]: Okay.

[Rx]: Most, not all.

[M]: Okay. But in fact, you say that the biggest limitation, it's the political matters more than the site itself.

[Rx]: That is correct.

[Rx]: And again you ask the politician. They'll push you out as far as they can. But further, you go out, more expensive becomes your pipeline, your design, your subsea on mooring systems. And that's a balance that needs to be made on a very high level and at some point, everybody will agree.

[Rx]: But this is a, in my opinion, it's a potato tomato market. It's much simpler than it sounds. It takes a lot of meetings with a lot of players, but at the end of the day it's just a North African market. You know, it is just hustling and at some point, somebody will win and then they find a compromise because it's about compromise.

[Rx]: Technically everything is possible. You could put all the FSRUs in the middle of the North Atlantic, but you would really pay a lot of money for the piping. It's not impossible, it's just really undesirable.

[Rx]: And that is a game that is played, and it depends on your area in the world. Not in my backyard is much more important in Western Europe than that It would be in Western Asia.

[M]: Yes, I mentioned in my thesis also about this problem. Another question because you mentioned it. About the FSRU project, it's specific to the location and the project and the demand of gas and what capacity we need. But based on your experience, is it possible to develop like a standardized FSRU model to create more vessels and to reduce the cost, or it's really impossible in practice.

[Rx]: I believe that we are more or less already there.

[M]: Ah.

[Rx]: Frankly speaking, the FSRU market was started by Exmarship Management with their first three vessels. Excellence Excelsior and Excelerate, which is now called Summit LNG, a vessel that I had the pleasure of commanding for three years. That was kind of the blueprint. Höegh¹¹ had the Cape Ann and the Cape Margaret which are not identical but very close to it.

[Rx]: And that's your first generation of FSRU and it's already a very streamlined model. Exmar in combination with Excelerate Energy has pushed another five or six of the same make onto the market, including the Express on which I'm now talking to you. And they all follow the

¹¹ Höegh LNG is a owner, operator of LNG vessel.

same design principle. They all came from the same concept. Then you have the very typically engineered one like the Toscana, which is a one off due to the way that the client and, and the owner, were combining to get where they wanted to get.

[Rx]: They wanted to do their own thing, and they set the standard very high because that ship kind of set the standard of what an FSRU could be in terms of how much fun technological toys can you add to one ship.

And I will say that they added a lot of really fun toys. It was a very impressive asset. Once again, we have to compare it to the year in which it was produced. Now you see that the new generations of FSRUs that come out, ... let's say blueprint Wise, it is still the same thing.

[Rx]: We see a little bit of variation in; in what I would call the goodies. Which kind of extras do you have? Do you have an MSO¹² compressor? Do you have a recondenser? Do you have a recondensing skid?

[Rx]: Do you have a post heater? But these would all be things that get bolted to the deck. In essence an LNG carrier is one of the most unified designs in shipping. There is no other type of ship that has been so much taken from a blueprint engineering design and that has such a copy paste history throughout every LNG carrier ever built, and technology moves ahead, and new equipment gets introduced and you see all that on newer generations, but still it's a very conservative design. It's very much a one off design compared to most other ship types.

[Rx]: An FSRU is still an adaptation to that underlying logic and where the changes could be made. And I'm excluding the Golar elements. Because they took it further but I am not very familiar with their ships. So, I don't want to talk about the Hilly and the GIMLI and I've seen aerial pictures of them and I'm looking at it and I'm mesmerized like: "what did they do ?!" but I cannot explain it because I've never been there.

[Rx]: Let's say I'm on dry land for that. I wouldn't want to have a judgment. But Most of the FSRUs that I see worldwide and we do get them also alongside in ship-to-ship situations where you get a first-hand view to these ships even if they're operated by other owners. Most of these are already very, very unified.

[Rx]: Whether you have a GCU or have a steam dump after your boiler situation, at the end of the day is not a big difference. It mostly identifies whether you were built before 2015 or after. I would say it in that way like it's already a one design kind of thing. And changes are going to be project specific.

[M]: OK

[Rx]: That's how I see it. The S188¹³ that you mentioned steps away from that quite a bit because it is barge based instead of ship based.

¹² « MSO » means « Minimum Send-Out Compressor ». It is the system for collecting the evaporated gas from the LNG wells, compress it to the desired pressure and feed the discharge header, so that minimum gas is sent out to flair header (to burn out the gas).

¹³ « S188 » refers to the FSRU S188 of Exmar which is a barge converted into a FSRU.

[M]: This FSRU is probably most like a prototype... like a standard FSRU in fact, no?

[Rx]: The S188, how I remember it from the press releases. Let me say this in a sensitive way.

[Rx]: How the press releases stated it at the time of construction, was that it was the typical Exmar gasification skid mounted to a barge-based platform with very limited, very limited storage capacity.

So basically, you cut the ship from underneath, you give it a small storage tank and you're going to moor it up to, to a bigger unit which has the storage capacity. And it comes down to the same logic of that second wave first generation. These early 2000s ships of 130k that are being phased out of the market because they're not so efficient anymore both in size and in propulsion needs. And that therefore became available relatively cheap.

[Rx]: And the idea was just let's connect them up to a barge rather than, rather than having a full ship converted. That was the concept of that project. And it has a client, so it works. I don't know how many of them they want to build more but it found a client as it very often goes.

[M]: Okay.

[Rx]: Most FSRUs have a client and find a spot in the world.

[Rx]: I would say if you operated a fleet of them, keep your design similar so you can rotate your people. That would be something that optimizes your operation. Industrialized production as you say, well definitely if you have 10 FSRUs and they all use the same pumps, you're going to get a different kind of price negotiation on bearings and impellers than if you would use 10 different manufacturers.

[Rx]: But to really say industrialize it in this, in the economic terms of a car manufacturer, there is just not enough demand for FSRUs to really industrialize it. How I understand it, I think there is.

[Rx]: Now you will know better than me the current number but there is what, 30 FSRUs in the world, something like that.

[M]: I count 47 and it count the floating storage unit also. It is like 10 FSU and the rest is FSRU. So, you are almost correct.

[M]: And new FSRU are under construction if I remember. I don't remember the company but eight more in progress, something like that.

[Rx]: Yeah, my company has one that is under construction now.

[M]: Yeah, but again sorry to interrupt you. I just have another message about the end of the meeting, but maybe we can start another one because I have few other questions. But we almost finished here as an interview. Because it's all one hour of interview, but it's very very interesting.

[Rx]: No problem. I have let's say half an hour more. Let's do one more and keep it there.

[M]: Okay, perfect. Maybe one last question before I restart. I think the link will be exactly the same than previous one. You can check but I will send you another email just in case.

[Rx]: Okay.

[M]: You already answered the question, but maybe you can add some details. Do you foresee an increase in conversion request in the coming year? Because you explained before that it's not really perfect solution. It's better to build directly an FSRU with the proper design, the proper power generation, the proper automatization resource like computer, like system. But is it really relevant to have a purpose build, or it's always a matter of cost...

[Rx]: I think that more and more, more and more we will see conversions because the cost of ship manufacturing has gone up a lot and that is a lot of steel cost also. So, in terms of economy, buying an old not so desirable hull is really outweighing building new. Just in terms of the cost of building new.

Then you have already your donorship and every bookkeeper and PowerPoint expert will be really happy to somehow conclude that it's going to be easier, which I as already explained, I do not believe it is, but that's what's going to be said.

[Rx]: And your timeline might be faster because once your hull is floating you only need a dockside, you don't need a dry dock. And not needing a dry dock might also optimize your cost, or at least your initial cost projection. A dry dock working on you alongside is not charging too much for being moored because they really like to work on your hull. And just a jetty is quite cheap. A dry dock, it's another running cost.

[Rx]: So, if you have to build it, keel up, you are looking at another timescale and add another budget.

Overall, seeing that ecological legislation is phasing out ships even faster than fuel economy and size efficiencies.

I'm imagining that we are going to turn more and more into conversions because ships are being phased out and actually have useful life left, meaning there is a created gap between market price and underlying value. And shipping is quite good at optimizing such gaps. So, yes, I see a lot of FSU and FSRU future for that whole generation of ships, especially looking at some transport players like Qatargas¹⁴, who are aggressively renewing their fleet and dumping the old fleet. That dump is now coming.

[Rx]: They have been aggressively renewing. They are in the middle of that process. Now is the time that we will start seeing the dump, because as the renewal comes in, it's first adding the new elements and then slowly seeing which ones phase out. And I'm imagining that those will find a way in this point of view or in the economic analysis on the secondary market, being bought for conversion or being bought for storage. I do believe that that logic will pick up.

¹⁴ « Qatargas » is a gas company from Qatar.

[Rx]: I am not aware at this moment. I have not been following the typical availability time for a spot in a shipyard. If you would want to buy one now. Honestly, I don't know. I know that a few years ago it was two, three years from booking the spot to putting water on your hull.

[Rx]: But now I have no idea what would be your typical timeline if you would try to build a new one. I have no clue. But yes, purely from an economic perspective, conversions is what will happen. I think that is sadly, the future.

[M]: Okay, but practically and for the environment, for example, it's not really the proper way, but the efficient way, at least...

[Rx]: Let's see. Yeah, fuel, propulsion, in terms of efficiency is measured in how much fuel per ton you push. Now, that is something that's been measured and quantified and regulated. Nobody regulates power production for the ship's use.

[Rx]: So there is a bit of a loophole in the legislation there where if you put an inefficient power generation on a ship that you only use to drive your regas¹⁵ plant, which is a massive consumer in terms of kilowatts.

It's a lot of equipment, it's a lot of consumption. Well, there is no regulation that stops you from running your pumps in whatever inefficient way you want. So even Europe has not understood yet this element. So technically there is nothing that stops you from having a very inefficient power generation running your FSRU.

[Rx]: And inefficient I'm just comparing strictly to the newest generation of LNG carrier coming out. I'm not talking about total efficiency of plants. Honestly, if you look at thermal plants shore side, you will never find efficiency numbers better than the first generation of FSRU. They're already much better than most things ashore. But in shipping we are striving for better.

[Rx]: And in shipping we are looking at chimney stacks, exhaust and efficiency of machinery systems. But we are never looking at the power generation internal to the ship. Because internally you need power to run two cranes, your galley and a fire pump and a toilet system. So, nobody ever cares what the ship produces for itself. An FSRU on the other hand, more like an offshore unit, takes the full power consumption for its own.

[Rx]: I am using more power to go full rate send out than what I use to go full speed ahead.

[Rx]: However, environmental legislations have imposed a power limiter on the rotation of my shaft and turbine.

[M]: Okay.

[Rx]: you see the joke there?

[M]: [laugh] Ha I see. Okay, I guess we finish all the question. Maybe I will just stop the recording and create a new meeting for the end.

¹⁵ « regas plant » is the regasification plant for FSRU.

[Rx]: Sure.

[M]: Normally it's the same link and the same password, just you can check. If not, I will send you an email.

[Rx]: Okay, very well.

[restart recording new meeting]

[M]: Okay, maybe one last question, but it's more a question about the prospective. In your opinion, what role will FSRU play in the energy transition or in the securing gas supply?

[Rx]: Ohh hummm [thinking] It's a very good question. I am not sure I've seen that until the Ukraine conflict arrived there was a huge momentum in Europe to. To push out all kinds of hydrocarbon fuel, jump straight to hydrogen and, and step to alternative power sources.

[Rx]: And since this conflict is there, there seems to be unannounced. It is not really published but there is a huge rethink in how we go around hydrocarbon-based energy in Europe for instance. But Europe is a main player on the market both for LNG and for FSRUs. So just to show that, let's say a small thing, if I may call it such that a small thing can have a big influence.

[Rx]: Looks like a lot of the alternative power ideas have gotten a new timeline 10 years further in the future. Looks also like there is a nuclear renaissance. These are things that I'm following from far away. I'm not an expert in those and multi geographic politics. It's not my cup of tea, it does not make me happy, and I don't understand it.

[Rx]: So I stay away of it as much as I can. Now where an FSRU fits in that I would kind of go with a simple statement, we're here already with FSRUs. It works; it's a proven concept. It's most of all, it's an amazing fast track to a lot of energy.

[Rx]: And that is a part that is not to be underestimated. At the end of the day, if you get your docks in order as a politician and you want energy, all you need to do is build a jetty and give me a flange and I will come to you with the storage, with the production, with the pressurizing, with the heating and with the operators to run the show. And all I'll be asking is a price per day and a flange. And that is a concept that in terms especially in a more turbulent and dynamic world, that's a very powerful product.

[Rx]: We see it also and that has always been broadcasted as such, mostly by Exmar but even Excelerate says it in this way. If you are a developing country, an FSRU is an amazing bridge. One of the advantages is also financing. Do not underestimate what an LNG shore terminal would cost.

[Rx]: And if you build it on your own land, but you are a little bit of a, let's say unstable regime, let's call it that. There is no bank in the world which is going to advance you \$2 billion for an LNG terminal in a country that may not exist tomorrow.

But if you say I want to invest \$100 million in piping infrastructure and I'm going to have a charter contract with somebody who supplies the concept, the technology and everything else and if I stop paying him, then I stop paying him and he just sails out with his ship and he goes

somewhere else for an even better price. That's something that a lot of banks in the world are much more willing to finance. So in terms of third world opportunity, we are not only talking about offering highly educated operators with highly technological equipment that comes as a package deal.

[Rx]: We are also looking at something that is much easier to get international financing for. And that's a concept going to be very powerful in developing a range of countries in Asia and maybe Africa. We were always thinking it was going to be Africa 15 years ago. But in reality, what we see now is we have two units in Bangladesh. We are, this is not a secret I'm telling you.

[Rx]: We are still discussing two more units in Bangladesh. We are supplying 30% of the gas consumption in Bangladesh already with two FSRUs. As far as that goes, you talk about a 200 million people country which is growing fast and needs all the energy they can get, but which has problems with education, and which has problems with securing financing because they are not the most stable of regimes. It's not only Bangladesh, it could be the next-door country, Birma. We are looking at India.

[Rx]: You could look at Vietnam, you could look at Korea. You can look almost everywhere in Asia, and there is people very willing to discuss an FSRU because the financial model of an FSRU based LNG terminal is more expensive on a 30-year period. But really gives you the fact that you can start, you have a model that is open sourced. It's the difference of paying the cash and paying it with a bank.

[Rx]: We all know that with the bank it's more expensive but sometimes we just don't have the cash to buy the whole thing today, before we drive it. And that's where financing comes in. And financing is something that gives access to energy markets for developing or unstable countries.

And that is something where an FSRU is a magnificent solution compared to almost everything else you have on the market. In Western Europe, even in the USA, in Japan, in very well-developed Countries with a high level of attention to environment. I do believe that eventually, the only advantages that are left are deployment speed.

[Rx]: You could get them fast. Also, in terms of legislation, you build a port infrastructure. It's easier to build than to build an LNG terminal because you are getting legislation for a jetty. And then we bring in a ship which is already under legislation with SOLAS. So, you kind of jump a little bit the legislative part compared to a full terminal.

[Rx]: So, you have a faster approval track and a unit that arrives. The technological advantage is not existing because the country has access to technology economically And ... Far for everything else I do believe yes, it can be a bridging concept for this you should read how the Germans are now reevaluating what they call the gas code which is the piece of regulation that controls how gasification is organized in the German gas network. They have retitled it to for the gas code for developing FSRU based import of natural gas in Germany. Freely translated, my German is not so good.

[Rx]: It is now called something like the gas code for importing natural gas in Germany through FSRU whilst preparing for transitioning to hydrogen-based energy. That that is already

happening. So, an FSRU is going to be in the civilized world. It's the jumping board to the next step of alternative energy. And I am a strong believer in hydrogen personally.

[Rx]: Maybe irrelevant because I have no expertise on it, but I do believe that is the future in terms of energy. Or we're not there yet technically, but it will be eventually. For third world countries, it's just an access system. It's a startup concept. It's something that gives you 30 years of access that you couldn't have otherwise.

[Rx]: That's where I believe is the position of an FSRU. Eventually it will fade to exist. But as said, some people went to throw sticks at each other in Ukraine and the complete energy transition of Europe was postponed with 10 years. Sometimes you don't need much to stay in existence. FSRUs were going to be phased out by 2030.

[Rx]: That's what they told us when we started. Well, I can only say it doesn't look like that today.

[M]: Okay, okay.

[Rx]: With all the new buildings on the market. So in the long run, very complicated.

[Rx]: I would say you are my generation. Ask your parents. In the 70s, in the 80s they were already promising that oil was going to run out by 1990.

[M]: Of course, this is THE argument and during my research, I look around also the different means of production of LNG and in fact the reserve of all the gas if we check all the kind of gas we can get, we have. We have plenty gas remaining. So, it's not a problem.

[Rx]: As long as there is gas, there is going to be somebody willing to burn it. For money.

[M]: Of course.

[Rx]: I'm always staying clear of the ecological arguments because I'm not in the best place to take a position, from every angle you take that both ethically and just [laugh] professionally.

[Rx]: But in reality, somehow the capital always wins from the theory. And as long as we keep finding gas, I do believe we're going to keep burning it for cheap electricity.

[M]: Yeah.

[Rx]: And an FSRU is a jumping board in that logic. So yes, FSRUs have a future, but everything hydrocarbon based eventually will fade.

[Rx]: Maybe not in 1990 like they told my father, but maybe in 2090, who knows. And it will mostly develop on. I think it will depend on how feasible our alternatives are. If we manage to make nuclear microreactors which are safe that are big enough to be implanted in heart rhythm monitors.

[Rx]: Then we are going to step away quite rapidly from hydrocarbons because we just have something better.

[M]: Yes, of course.

[Rx]: We don't have that yet.

[M]: Something I would like to mention also because you speak about the FSRU position. Do you know that in France we put a new FSRU for two years or two years ago, something like that.

[Rx]: In Brest ?

[M]: No in Dunquerque or Le Havre. The Cap Ann FSRU is chartered by Total. The problem is...

[Rx]: Sorry, not new. That's a 15-year-old ship, no?

[M]: Euh yes, yes, yes. But of course the deployment was relatively new.

[Rx]: Yeah Absolutely.

[M]: The problem is it was a political decision just to take a reserve from. Because of the war in Ukraine.

[M]: But the problem apparently for 6 months they didn't receive any LNG cargo for 6 months. Apparently, they put a new FSRU in case of demanding for new demand. But it was not necessary. So, it was fixed for five years. Chartering contract for five years, but we are already at the middle of the contract. Apparently it was a waste than really efficient.

[Rx]: Yeah.

[M]: So, it really depends on the country, I guess.

[Rx]: Correct. And the gas market is a. Is a very volatile thing.

[Rx]: That's what I've seen in my 15, 20 years in it is that product price and charter prices. It dances in ways which even for shipping are hard to understand. And then you go to something as specific as an FSRU you get the same with an exponent on it. I'm sorry to hear Cap Ann is not operational, ...

[M]: It is operational.

[Rx]: but in terms of energy...

[M]: It is operational but apparently no trading at all.

[Rx]: Yes.

[M]: And during this time, you have to pay, the vessel, the crew and the position, but no cargo is coming. So that's very strange.

[Rx]: That is painful. I would advocate it. Advocating the devil maybe. I don't know.

[Rx]: I'm not very familiar with the Cape Ann situation, but there is a point in energy it is the total collapse theory, which is that if you need 100% of energy, you are going to need to produce ... You will need a facility that can produce 120 because you have peak demand, you have lower demand and then you would like to have some redundancy because the second you go, the second you under produce your consumption... is actually the minute that your whole system collapses and everything that was still running will collapse with it because almost everything is rotational.

[Rx]: And all the rotational equipment is going to overspeed and then trip on self-protections. Whether it's a steam turbine, a gas turbine, any heat-based energy production, which is almost every energy production maybe excluding some fancy alternative processes that don't really produce energy. They just look good in terms of production. They are almost all marginals.

[Rx]: Both solar, wind, it's all marginal. It's not really producing. It just looks good. I mean just look at kilowatts per hour and then we discuss again. It's too small to be relevant.

[Rx]: But even wind is mostly rotational and the moment you overspeed it, it trips. It trips not to blow up.

The moment you would have a higher demand, all your governors, all your equipment is going to speed up to follow on the demand. All your equipment cannot follow because you demand too much. And all your equipment actually does like what they call sympathy trips. It trips itself out of sympathy with the original trip.

[Rx]: Which is why you would want to have 120 to 150% production capacity compared to your consumption. Avoiding this full collapse of your system where you drain out all the energy. After which starting up again becomes much, much more difficult. I don't know what happened in Spain and Portugal¹⁶.

[M]: Yes, I was thinking about that also.

[Rx]: But it feels what I hear in the news, and I don't know more than you, maybe I know less what I hear in the news. It sounds a lot like that: Once you manage... I think it is this famous movie in one of the "die Hard". I think it comes the fire Sale.

[Rx]: You know, it's a bit the same concept. Once some of them go, if you manage to get a few critical elements out, the whole system actually implodes. And that's why you would put an FSRU on idle just to be ready to start something if you need it.

[Rx]: And that's where your Cape Ann on would make sense even if not one molecule of gas comes out for the full five years. You bought a certain, a certain kind of robust.

[M]: Yes. A certain buffer in fact.

[Rx]: Yes, that's, that would be the justification.

¹⁶ Two days before the time of the interview, there was a total blackout in Spain and Portugal in May 2025.

[Rx]: And I have worked in an environment this I can tell you it is Bangladesh. Where structurally they are under producing the power they need, and they are all the time blocking out cities just to keep their network alive.

It's very fascinating to be on an FSRU in such an area where everything that happens to your pumps is like nation critical [both laughing]. It's an interesting commercial situation to be a captain, I will say and I'm grateful for the opportunities for growth, let's put it that way. It's a very nice way of saying how much I was fucked every day.

[Rx]: But yeah, there you have the other end of it and that's that you're all the time shutting down hospitals and entire cities because each time there is a piece of 60-year-old charcoal equipment that fails, your whole network risks to be imploding.

In Europe usually we manage because the networks are connected, and we can go buy across the border

[M]: Yes, yes, yes.

[Rx]: because we have a multi node network that works quite well. An FSRU is a ... thinking] safety margin at that point it gives you. It gives you just that 10% even if you don't use it.

[Rx]: I don't know how much percent France needed so I will not say if it's a fair choice or not. This I don't know. But I would say even if it doesn't work strictly as a redundancy, it might be a relevant decision. But I would not like to be the spokesperson to the media to explain this [both laughing] because they will eat me. [laughing].

[Rx]: But there is a point to it. There could be a point to it.

[M]: Okay.

[Rx]: Sometimes it does make sense from that angle, but it's not some... Well, you cannot explain this in one page and therefore nobody wants to read it.

[M]: Yes, of course. By the way, I find the perfect report of this FSRU. It's a public publication in France, but it's written in French of course.

[M]: There are very precise information about position, ship recommendation... It was quite a big project. As you mentioned, it can be a relevant investment just in case of lack of energy. But it's difficult to predict this kind of trouble.

[M]: So, we arrive at the end of the interview.

[M]: I check my bonus question, but in fact you already answered it during the interview, so I think I will not ask you more.

[Rx]: One of your bonus questions we should address specifically. I'm going to them also now. One I didn't say. What about nitrogen generation systems?

[M]: Yes.

[Rx]: If you are strictly talking about service nitrogen, meaning what we use to purge manifolds and for certain works of cleaning up pipes on deck.

[Rx]: Yes, you should supersize your existing system and, and you cannot underdo it. And that is not real money actually. That is something where you would want to adapt your donorship. A typical LNGC as we call it, a typical LNGC does not require as much nitrogen like a typical LNGC will have between 100 to 200 cubic meters per hour production. I would suggest 800 and require 400.

[M]: Okay.

[Rx]: It is done with less and it is possible. But in terms of operational reliability and in terms of time management during your operation, you are talking about \$200,000 investment that saves you maybe four hours per week for the rest of your ship's life. That's it's a very good question because it's very often overlooked and, it really changes how we do things on boots on the ground.

[M]: Okay, so this is the point very, very important in fact. Okay, all right.

[M]: Ah yes, maybe I have another question. Because I work on a ship with a reliquefaction system. It was put it as like a prototype just to check if it can keep more boil of gas and reduce the cost.

[M]: I talk with some engineer, and they explained to me that it could be a good solution to "clean the gas" because as you know, the gas can have different composition, or you can have more nitrogen more methane ethane ... depending on the composition. By using the reliquefaction system. It was a SMR system. I don't know if you know a little bit this kind of system.

[Rx]: I've worked with them on LPG.

[Rx]: Okay.

[M]: It was a complex system and most of them, they don't really know how to use it properly.

[Rx]: Okay, yeah, It's famous. It's the system that they use on the Q flexes. Huh?

[M]: Yeah maybe.

[Rx]: And it comes, it comes in a variety of generations and all of them have the same problems in terms of cleaning. What you would do do that I can see immediately is income.

[Rx]: Incompressible and incondensable gases are going to accumulate in the top of your heat exchangers and you could easily automatically vent them off in which way you would indeed get your nitrogen out. And that is correct. Now nevertheless, I will immediately counter this statement with the following. You are having a 40,000 cube tank and you are recondensing three cubes per hour. How much time would it take to clean your tank?

[M]: Ah a lot of time.

[Rx]: Yes, so the theory kind of fails in the numbers. And it's a typical misunderstanding for reliquefaction systems on gas carriers is where you are cooling your tank is by removing the vapor, by lowering the pressure, the liquid cools down. You don't cool it down because you inject some super cold liquid. That is irrelevant.

[Rx]: If you take the temperature of the re injected liquid. Even if you re inject it for LNG at minus 200, which you cannot, it's still three cubes in 40,000 at minus 200 compared to minus 160, your thermal efficiency of that interaction is 0, 0.0000 something. Your real efficiency is in removing the vapor. And then you either burn it or you reliquify it. Now the problem that I've heard of most of these systems, and we did at some point in a different company look at buying one of those.

[Rx]: The main issue that most of these systems have is that they consume more gas than they generate. Meaning the power, they need to run is actually higher than the efficiency they create. And that's been something they say, and this is hearsay. I'm now the official ship radio of the Indian Ocean [laughing]. Because I don't know this, but the word on the street, radio, WhatsApp, however you want to call it, word on the street is that the latest generation would be almost efficient.

[Rx]: Then a technical challenge all of these systems are having, and this is nothing new, this was already true in LPG days, is they're extremely sensitive to the temperature of the water you use for your intercoolers. And for instance, in the Persian Gulf the water would just be too hot and your whole system would fail.

And that's something that the Q flexes as per the radio because I never sailed on them, but that's something that I heard the Q flexes are heavily struggling with is that their liquefaction actually starts working one day after Hormuz. So the first three days after loading they have no reliquefaction. And they're all sailing around with their vent masts.

[Rx]: Well, I will not say wide open, but almost open.[both laughing] You know, I was never there. I cannot tell you. But that's kind of what happens on a lot of these ships.

[Rx]: So, these reliquefaction systems, yes. On LPG it works perfectly, but you are looking in a different pressure and temperature range and somehow efficiency is different for those machineries. The theory fits perfectly for LNG. What I see now is there is a tendency now to start looking at recondensation rather than reliquefaction.

[M]: Yes.

[Rx]: And that seems to be. And I have to be very careful what I say here because both companies I worked and work for have patents in this field. But I will say I've worked on a few varieties of that logic and they all work.

[Rx]: And the last point, back to the reliquefaction on LNG. Yes, your statement that not everybody knows how to run these things. They seem to be some special kind of "black magic". That's what I understand from everybody that talks about it.

[Rx]: That might be lack of training and it might be that these machines are actually too complicated to be operated. I mean, I would not be able to drive a Formula one car, but I could

also not buy it on the normal car market. You know, if something is that complex, maybe it should not be pushed to market. But yes, they have a very poor reputation in the industry. But I am really not talking out of my brain.

[Rx]: I'm talking out of my ass when I say this because a lot of this is not something I know for myself, but I do. Well, please, when you write this down, you may want to rephrase me here, but yes, I have the same impression. Absolutely. Okay. Not a big fan of reliquefaction.

[M]: Okay. All right. I guess we have finished the interview. It's like one hour and 40 minutes.

[Rx]: Okay.

[M]: Do you have any remark?

[Rx]: Thank you for listening. I believe that, let's say, as far as my perspective on average reviews goes from the angle of your question, I think I've covered the angle with everything I know.

[M]: Okay.

[Rx]: I don't know anything more than what I've told you [laughing] See it in that way. If something specific would come up, drop me an email.

[Rx]: I'll be happy to answer. I'm going home somewhere next week. I'll be much less reachable after that. I'm just very, very realistic about my family and garden life.

[Rx]: That is just taking over. And I switch off telephones and everything else. But if you say specifically, can you look at this or what about that, I'll be happy to drop you a line back and for everything else, I wish you really good luck.

[M]: Yes Okay. Just to add a little feedback. It's just very interesting interview because you had a lot of information and some information I never think about. It will be very valuable for my research, and I would like to thank you for that.

[Rx]: Maybe see you on board one day.

[End of the interview]