Joris van der Schot (00:00:00):

The flow that I've always been interested in professionally is this Niagara of oil that feeds our global metabolism. Because indeed, man, unique among living species on Earth, is the only one who has managed to create a metabolism outside of his own body.

Nate Hagens (00:00:26):

Today's guest is Dutch energy expert, Joris van der Schot, currently living in Switzerland. Joris worked at Royal Dutch Shell for over a decade as a refinery expert, an executive at Shell before turning his attention to the clean energy transition. He now works for a French scale-up Energy Pool, providing flexibility services to the electricity grid with a focus on energy storage. We today talk about oil refining. This incredibly complex process that is in between the oil from the ground and the gas at the pump. How flexible is it? How does it work? We used his son's Legos to demonstrate the cracking and distillation aspects. This was a very interesting conversation. Please welcome Joris van der Schot.

(00:01:22):

Joris, grüezi, or what do they say in your part of Switzerland?

Joris van der Schot (00:01:42):

Yeah. I'm actually just across the border. I'm in Jurassic Park. Can you believe it?

Nate Hagens (00:01:50):

Jurassic Park.

Joris van der Schot (00:01:51):

And they say bonjour in this place here.

Nate Hagens (00:01:54):

What's Jurassic Park?

Joris van der Schot (00:01:57):

Well, the Jurassic was named after a mountain range where they found these fossils and that happens to be the Jura Mountains, which are, if I look out of the window, this way. And they face the Alps, which is if I look out of the window, that way.

Nate Hagens (00:02:15):

Okay, I didn't know that. I'm sorry I missed you last week, but it was a hectic trip through Geneva. All I saw was the airport. So, maybe next time.

Joris van der Schot (00:02:27):

Pleasure.

Nate Hagens (00:02:28):

So, you are the first guest on this show who is an expert in oil refining and hydrocarbon refining. You had a career at Royal Dutch Shell, now you're working at electricity, renewable grid balancing outfit. And we can talk about that later. But let's take a deep dive because I want to really understand personally and for my viewers, the refining process and how central it is to our modern world. But let's first take a step back. You mentioned Jurassic. How did you become interested in energy? And I know some of your writings, you talk about humans as pyromaniac and the importance of fire in our evolutionary trajectory. Why don't you give us opening overview?

Joris van der Schot (00:03:30):

Yeah, sure, Nate. Maybe just for the background, I'm an engineer. I'm just a very simple engineer and I like you to understand the world in simple engineering terms. I specialized in something that you'd recognize as system dynamics, probably stocks, flows, feedback loops, which is of course the science that underpinned limits to growth, the report to the Club of Rome. And the flow that I've always been interested in professionally is this Niagara of oil that feeds our global metabolism because indeed, man, unique among living species on Earth, is the only one who has managed to create a metabolism outside of his own body.

(00:04:27):

There are the calories that we eat like any other animal, but there are also a lot of calories that we burn outside of our own bodies. And this started with a simple campfire where we cooked food really, which is partly reason why we're in a kitchen here, but it turned into something that has really been powering modern civilization. And these little campfires today have really grown in scale to what I refer to as a Niagara of oil. And maybe it's helpful for people who know Niagara Falls to picture yourself standing there. I was there as a kid. I lived in Woodstock for a year and we drove up to Niagara Falls.

Nate Hagens (00:05:15):

That explains a lot.

Joris van der Schot (00:05:19):

Yeah, people with crazy ideas. I get it. And we drove up there. And when you stand next to Niagara Falls, I don't know if you can imagine it, but you see this enormous mass of water flowing across the edge second after second, after second. And I'm talking about the American Falls, not the Horseshoe ones. And you could actually feel it in your gut and you hear the thunder of this thing. Now, maybe I was little, but I think it's still like that. And when I looked for an image to convey the scale of our world energy system, I thought if you can imagine Niagara Falls flowing not with water, but with oil, then you have a very good sense of the size of the world energy system that is the size of our global metabolism these days.

Nate Hagens (00:06:14):

24/7 flow.

Joris van der Schot (00:06:17):

24/7. Yes. If you're in Europe, Rhine Falls is something similar. I visited this summer actually. Now, it's not all physically oil. It's oil equivalent. It means if you add up all the energy we use in the world like they do at the International Energy Agency in Paris and convert that to oil equivalent, then you find a flow rate that's very close to the flow rate of Niagara Falls. Ninety percent of that is stuff we burn mainly coal, oil, gas, a bit of biomass, 5% is nuclear, 2.5% is hydro, mainly large scale hydro. And about 2.5% is all other renewables combined.

Nate Hagens (00:07:07):

So, how much is coal, oil, and natural gas?

Joris van der Schot (00:07:10):

I'd say about 80%. And there's actually a small 10% of biomass like just firewood and other biomass.

Nate Hagens (00:07:19):

So, where do we burn this generally globally?

Joris van der Schot (00:07:24):

That's the interesting part. Actually, this IEA website is very helpful for that, although it's down temporarily. They break down this energy flow in a Sankey diagram. It must be the name of the inventor of that type of diagram, where you have the sources of primary energy on one side and the end use on the other side. And the end use will be transportation and industry, other, and non-energy use. I think that's the way they cut it. And then, you have these flows that connects, oil goes into this use and gas goes into that use. And the width of each of these lines is proportional to the importance of that flow in the world energy system.

(00:08:14):

And what you see is that the vast majority is indeed these hydrocarbons and there's a very thin line which is renewables today. And of course, that's the part that's growing that we need to grow. But in between these two, end use and source, there are two little boxes of transformation. And those are actually quite interesting and we don't think about them very often. There's about one-third of this energy goes straight to the end user, generally fixed sites. So, let's say natural gas into a home in Holland where we heat our homes with natural gas.

(00:08:58):

There's one-third that goes through power stations, all the world's power stations, typically coal. Few people have a direct use for coal. It's mainly used in power stations to generate electricity. And then, of course, you have some losses. But there's one-third that passes through refineries, oil refineries. And I think we don't talk about those too often there. They're not very sexy, but they are actually quite important for the world energy system because these oil refineries function in a similar way that mitochondria would work in the cells of your body and every life form.

(00:09:44):

So, these oil refineries are like the mitochondria of, I think you call it the amoeba or the Superorganism, that is our global society in the sense that they provide the energy molecules to society. Mitochondria provide the ATP. It's a special molecule that is the energy currency of life. And these refineries, they provide liquid fuels. So, it's not a single molecule. It's a collection of molecules, but it has the same function.

Nate Hagens (00:10:19):

So between extracting the hydrocarbons out of the ground and them becoming the ATP for our global society in the form of diesel and gasoline, they need to be transformed. Oil is not gasoline. Can we use oil directly out of the ground for anything? Is some percentage of it used just straight as is or not?

Joris van der Schot (00:10:46):

No. I think maybe in ancient history, people may have used oil that just was seeping out of the ground just to light some fires or something. I've heard, but it's a tiny amount that there may be the odd power station in the world where people burn oil directly, but really, there's a lot of value add in separating out the oil into different products and then each product goes into a particular end use.

Nate Hagens (00:11:22):

I'm quite likely to ask you some naive questions in the next 30 minutes. If you pulled some oil out of the ground and spilled it on the floor and struck a match to it, would it light on fire the same way that gasoline would?

Joris van der Schot (00:11:37):

Look, I've never tried, but it would light. Yeah, yeah, definitely. But oil is a very... how should I say? Is a very diverse term, almost like coffee. If you have a coffee in one place or in another place or in one country, in another country, yeah, it's the same name, but it's not like a McDonald's hamburger that is rigorously the same everywhere you go on the planet.

Nate Hagens (00:12:04):

Except in Hong Kong. The ketchup is green on Big Macs.

Joris van der Schot (00:12:09):

Oh, really?

Nate Hagens (00:12:09):

Yeah, but go. I digressed.

Joris van der Schot (00:12:11):

And the French have their own version as well.

Nate Hagens (00:12:12):

Okay. So, oil is different. And why is that important?

Joris van der Schot (00:12:18):

Well, look, it's got to do with the way... actually, it's just the way nature is, right? So, it has to do with the way that these oil fields have come into existence. And I'm not an expert in geology, but basically, of course, oil is fossil sunlight. And under the influence of pressure and temperature in the earth's crust, these old plants or dead dinosaurs or whatever they are transformed slowly. They're decay into oil. And that's the reason that we talk about hydrocarbons. The thing about carbon is these things are based on carbon because life is carbon-based.

Nate Hagens (00:13:07):

And our economy is carbon-based.

Joris van der Schot (00:13:11):

Our economy is carbon based, yeah. And so, that is the reason that these different oil fields are just at different levels of maturity, so to speak. And I think and I'm not 100% sure, but I think actually, the latest stage of this is natural gas. That's like the furthest form of decay. Once you're there, you can't decay anymore. But all the others, they're like intermediate forms. And there's actually one interesting thing in Holland that really caused a big economic boom in the 17th century for us, which we call our Golden Century, which is peat. I don't know if you've heard of peat, which is dead plants, but only a few 1000 years decayed.

(00:14:04):

So, they still look like rotten plants almost. And if you do that for 100 million years, you get oil.

Nate Hagens (00:14:15):

So, is it fair to say that of all the different grades of oil and hydrocarbons from oil shale, which is uncooked oil to peat to tar sands, all the way to light sweet crude, their mother nature has spent various times refining that and human oil refineries around the world transmute those substances into uniform products that are used in the world's machines? Is that fair to say?

Joris van der Schot (00:14:58):

Yeah, ish. Yeah, that's pretty much it. Yeah. The function of these refineries is to say, look, these oils are very different from one side to another, but the end use is actually fairly standard. A car engine needs to accept the product. And so, our job as refiners is to make products that are on spec for the customer, and that meets certain specifications. And within that spec, there's still quite a lot of variability between whether your base oil came from the Middle East or from the North Sea or something. But it's all fit for purpose for the customer. And there are stringent specs that you sell against.

(00:15:50):

But the interesting bit is when you buy oil, there are no specifications. Can you imagine that? There's no specifications. So, you write a check for, well, what's a big VLCC? Two million barrels. Let's say $100 a barrel. So, you write a check for $200 million to some guy saying, "Well, look, here, you've got a ship of oil, no guarantees."

Nate Hagens (00:16:17):

Wait a minute, those ships, VLCC, what's that stand for? Very large?

Joris van der Schot (00:16:22):

Crude carrier.

Nate Hagens (00:16:23):

Crude carrier. They carry around $200 million each of oil on one shipment?

Joris van der Schot (00:16:31):

Oh yeah. Well, they carry 2 million barrels. Well, you're an economist.

Nate Hagens (00:16:35):

Yeah, 2 million barrels. And so, when you buy that, when Royal Dutch Shell where you used to work buys that, you could get it from the Urals or Brent or West Texas or refined tar sands or whatever you have agreed to purchase. And then, it comes into the refinery and then experts like you have to figure out how to make that grade of crude oil, which is very different from around the world into the very specific products.

Joris van der Schot (00:17:11):

Yeah, indeed. And many refineries specialize in treating certain types of crude.

Nate Hagens (00:17:20):

I would assume that the refineries specialize in crude, that's more available in their region.

Joris van der Schot (00:17:26):

Yeah, for example, but it's a whole economic trade-off. For example, so I worked in a rather large refinery in Rotterdam. So, Rotterdam is a good place for a refinery because it's one of the biggest ports in Europe. And we had an advantage of scale. It was a big refinery. I think we transited about 0.1% of global energy use, went through this single refinery of two square miles or something, 25 gigawatts of energy products, molecules. So, not electrons but molecules. And yeah, that's quite sizable. So, if you have size, you can take different types of crudes for example, and you can say, "Well, my base diet..." we call it a crude diet, by the way.

(00:18:32):

"My base diet is going to be Middle East, Arab Light or Arab Medium. We took some Arab Heavy as well, the odd Kuwait, but I'm also going to take the occasional crude from Russia at the time." Can't do that now. But at the time, Russia was still a trading partner. So, you can buy crudes or maybe some other crude that comes from Brazil. And that has a bit of an odd quality and that other refineries can't take because it doesn't fit their kit. And you can just blend it away at 5% or something. You can blend anything away just as in the kitchen. It's the same thing.

Nate Hagens (00:19:23):

Okay. So, when we first met, I don't know when that was, a year or two ago in a very informative way that I hadn't seen before, you showed me some Legos that represented what happens in refinery. Did you set those up today?

Joris van der Schot (00:19:44):

Yeah, yeah. I went back to my youngest room and plundered his store of Legos to talk a little bit about oil.

Nate Hagens (00:19:56):

So, why don't you break it down for the viewers, Joris, on how oil gets refined using your son's Legos?

Joris van der Schot (00:20:05):

So, here, we have an example of the different molecules that are in oil physically, and I've already sorted them to make things easy. So, oil is basically carbon-based. And here every Lego that you see, every little round dot is one carbon atom. You have to imagine. And by default, every carbon atom will connect with four other atoms. So, on each side, you have to imagine for this particular one that there's a hydrogen, but I'm not showing the hydrogen. I'm not showing hydrocarbons. I'm just showing the carbons because it gets messy otherwise. Now, an oil is a mixture of different chains of carbon chains of hydrocarbons that can be in any shape or form. The ones I'm showing here are mainly linear, but that is not necessarily the case. So, there are millions of alternatives to the ones that I'm showing here. Well, we could say hello to a couple of them. This very simple one, you may recognize it, Nate. We call C1. So, one carbon atom. It's methane, natural gas. So, when you heat your home with natural gas, this is the thing that you're actually burning.

Nate Hagens (00:21:34):

With four hydrogens. So, you would need Tinkertoys to demonstrate it correctly.

Joris van der Schot (00:21:39):

Yeah, exactly. Exactly. And then, actually, when it's in the ground, that natural gas actually comes generally with a couple of the longer ones. That's what we said previously, right? It's never completely pure. So, it comes with the second one, C2. This is ethane, it's called ethane. And that's not very well-known. So, in a refinery, if we go to that, these are a nuisance. So, they're generally burnt. They're used as refinery gas we call it. So, to heat the refinery itself. Here, we've got C3. We call it propane. Maybe your house is heated with propane if you live out in the countryside.

Nate Hagens (00:22:21):

It is.

Joris van der Schot (00:22:24):

C4 is butane. As soon as you get beyond four, you can see that there's two options to combine four carbon atoms. You can do a linear chain or you can do this little Tetris form here. And that can happen for all of these. So, that's where you get the complexity. And that's actually why life is carbon-based, is because you can make all these complex molecules with carbon atoms.

Nate Hagens (00:22:58):

And why does that mean life is carbon-based? Because other types of atoms wouldn't have that flexibility and Lego like-

Joris van der Schot (00:23:10):

Yeah, indeed. If you take oxygen, for example, life is not oxygen-based or not primarily oxygen-based. Because oxygen can only make linear change. So, you can't create DNA out of oxygen.

Nate Hagens (00:23:28):

Here's another naive question. So, a low-carbon future based on what you're saying implies a lower scale energy future and a lower scale consumption future more than likely just based on first principles.

Joris van der Schot (00:23:51):

Well, you can find alternative sources of energy. But yeah, a low carbon future means burning less of this stuff because this all becomes CO2 when you burn it.

Nate Hagens (00:24:02):

Right. Okay, we'll talk about that later. Keep going with your example.

Joris van der Schot (00:24:06):

Yeah, sure. So, here you've got a range of molecules, and maybe let me just quickly finish this. So, here in the middle, you've got things that go into mogas, gasoline, sorry. This would be something that goes into kerosene, jet fuel, and then a bit heavier is diesel fuel typically, right? I'm just schematizing. And then, here over here on the right, you'll see I took two big ones that have a lot of carbon atoms. They're not actually arranged like that, and I made them black because when you distill a crude oil, this is the stuff that is actually black, these very big molecules, and all of these become transparent. They are transparent. It's just when they're mixed with these guys, the oil overall is black.

Nate Hagens (00:24:58):

So, when oil comes out of the ground, it's black, but when it's refined, there's a bunch of products that are clear or transparent. And then, the black color stuff sinks to the bottom and is asphalt or-

Joris van der Schot (00:25:10):

Exactly, yes.

Nate Hagens (00:25:12):

Got it.

Joris van der Schot (00:25:15):

A refinery basically has three functions. The first one is just sorting these molecules. The second one is cutting and pasting, and the third one is treating the molecules. So, if we start with sorting molecules, we basically call that distillation. It's done with heat. You can imagine if you have a pan or a distillation tower with all these molecules mixed up and you heat it, then the lightest ones are going to evaporate first. And there's actually a heat profile in these columns which causes these fractions as we call them, fractions of the barrel to separate into different cuts. And you extract them from the distillation column in different cuts.

(00:26:10):

Typically, for example, these two guys, they might go together, C3, C4. They can be sold together as LPG, right? And then, maybe in the next column, they're separated out into propane and butane because we want to sell those separately, for example. But the most important cut is on the heavy end where you separate what we call the residue from the transparent products. This stuff is generally worth less than crude, and these molecules are generally worth more than the crude oil that goes into your column. So, that's the basic economics of this.

Nate Hagens (00:26:52):

So, what does the yellow represent on the diesel?

Joris van der Schot (00:26:55):

The yellow ones here are sulfur atoms. And they're considered as impurities that need to come out of your fuels for different reasons. The third function of the refinery, cleaning the molecules, is mainly about removing these yellow bits that represents sulfur. Now they can be attached to all of these. I just had an example here in the diesel one, and it's roughly proportional. So, this would be a medium sulfur crude with about five atoms of sulfur for, well, I haven't counted it, but something like 200 atoms of carbon.

Nate Hagens (00:27:40):

And is the sulfur in all oil or does some oil have a lot more sulfur?

Joris van der Schot (00:27:46):

Oh, it's a very big difference. It's a main differentiator for crudes and it's a main determinant of their value because not all refiners have the equipment to remove the sulfur.

Nate Hagens (00:27:58):

And why do we need to remove the sulfur?

Joris van der Schot (00:28:01):

Mainly two reasons. Historically, it's been about acid rain. And actually, I think that is a pretty nice example of how regulated capitalism can work, at least what I've seen in the Netherlands is your company goes out and delivers some product and at some point, society finds that there's a problem with your product. And then, you sit around a table and you say, "Look, this sulfur is causing acid rain. We've got to do something about it. We realize you can't do it tomorrow, but let's start a plan to reduce sulfur over time." And so, that's what has happened in European refineries and I'm sure it's the same for American refineries.

Nate Hagens (00:28:50):

Now, I'm not expecting you to be an expert on this, but I have heard that one of the explanations for the record temperatures this summer and yesterday was announced that September was the all-time hottest September in recent times was because of the lowering of sulfur content in marine fuel due to environmental regulations has reduced the masking effect of sulfur particles and therefore in the short term boosted global warming. Do you have any thoughts on that?

Joris van der Schot (00:29:28):

Oh yeah, sure. Marine fuel is the black stuff, right? We hadn't quite finished our distillation, but this residue is not thrown away. It's going to specific uses which are bitumen and marine fuel basically. Big ships, they have engines that can handle this black stuff. And as you can see-

Nate Hagens (00:29:55):

What is bitumen?

Joris van der Schot (00:29:57):

Oh, sorry, asphalt, the stuff you make roads with.

Nate Hagens (00:30:02):

Right. But isn't tar sands also called bitumen? And does tar sands not need to be refined as much and can be used as asphalt?

Joris van der Schot (00:30:13):

I'm not an expert on tar sands, but by the name and by its reputation, it's extremely heavy crude and it's mixed with sand, right? So, you're going to have to separate out particles of sand. I don't know how they do that. But the other thing is it's got a huge proportion of this black stuff and not much of this white stuff, so maybe only this much or something. So, what you then have to do with tar sands, and that brings me to an intermediate function of a refinery. We said the refinery needs to sort these molecules. It needs to treat the sulfur, but it also reforms molecules. It cuts and pastes molecules. And this guy in particular, it goes with the residue. It's called vacuum gas oil.

(00:31:16):

It's distilled out in a separate column and then it can go into what we call a cracker. In America, you have cat crackers, which means catalytic crackers. Hydro crackers are more in Europe or you have thermal crackers. All of those, what they do is they just cut these large molecules into smaller ones so that this guy can now go into diesel and maybe this guy can now go into gasoline.

Nate Hagens (00:31:43):

So, how do they cut them mechanically? How does that actually happen?

Joris van der Schot (00:31:49):

So, the brute force is temperature. You heat it up enough and at some point, they will crack. They will just break. And then, there are smarter forms. If you use certain catalysts, that's cat crackers. Another form to do it is you do the same thing in a hydrogen environment, catalyst and a hydrogen environment, and then you get a hydrocracker. And one will crack it more into diesel components. Another the cat cracker will make more gasoline components, for example. Now the tar sands that you were talking about are a lot of this very heavy stuff. So, they will need a lot of cracking, upgrading, they'll probably call it.

(00:32:39):

To come back to the sulfur though, the marine fuel you are asking about, it used to have a specification, and I must say, I might be slightly outdated, but there were two specifications on the ocean because we get the sulfur out for acid rain. But out on the open ocean, sulfur is less of an issue because there's no forests.

Nate Hagens (00:33:15):

Yeah, but those clouds eventually make their way to land somewhere.

Joris van der Schot (00:33:21):

Yeah. Look.

Nate Hagens (00:33:21):

Okay, sorry, sorry, keep going.

Joris van der Schot (00:33:25):

I'm not the right person to have the exact rules on that. But unlike CO2, because people mix up CO2 and sulfur very often and get it completely mixed up. So, unlike CO2, sulfur is more of a regional problem. So, if you have a ship out sailing in Antarctica, the sulfur it emits is not going to be a problem in forests. So, for a long time, these fuels have admitted quite a high percentage of sulfur. I think it was 4.5% or something. And then, the regional seas, like the North Sea, so around the continents started implementing low-sulfur bunkers or enforcing low-sulfur bunkers because they found that the ships that were sailing close to the shorelines did actually impact acid rain.

(00:34:22):

And there's a couple of other environmental issues with sulfur as well. So, they started regulating this to 1.5%, but now, the global specification has been lowered. I don't know to what level, but I am pretty sure that that is the reason why there's now less sulfur emitted and these sulfur emissions, they cause particles up in the atmosphere that partly reflect sunlight, which is why they depress temperatures. There are these geoengineering schemes where people want to inject particles into the atmosphere to reflect sunlight. So, we're all less warm, but sulfur does some of that by itself.

(00:35:09):

So, if you remove the sulfur from your fuels, I can imagine that you have a temporary impact on that. Yes.

Nate Hagens (00:35:15):

Great. Let's reduce the temperature and kill all the trees. I'm partially kidding. Okay, so let's get back to the big picture here, Joris. I'm sure you've watched my frankly series on Just Stop Oil on refining. And I made, not a detailed, but just a general observation that if for some reason we didn't need gasoline because we had all electric cars, for example, I argued that at least in the near term, it would not significantly change the demand for oil or the need to extract the same amount of oil, like 30 billion barrels a year that we're extracting because of what you just illustrated that gasoline is, but one of those white series of carbon atoms that we get from a barrel of oil.

(00:36:22):

And if we still had the demand in the global economy for all the other things, we would roughly need the same amount of oil. What are your thoughts on that?

Joris van der Schot (00:36:35):

Yeah. Look, I think on the short term, you're right. These refiners, they have what we call the butcher's problem. A butcher cannot only sell T-bone steaks. He has to buy an entire cow and he's got to sell every part of that cow. So, if there's a reduced demand for one of the elements, he still has to sell these other elements. But I think what happens in the oil industry historically is that if you give it enough time, well, on the very short term, like today or tomorrow, there is flexibility in these refineries to some extent.

(00:37:24):

So, for example, there are molecules, let's say the C10, the one that's 10 long, it might go into gasoline and your car works fine with it if it's a part of it. But you can also cut it into the jet fraction. So, these are distributions, these cuts of the barrels or distributions, and so you can play a little bit with those distributions.

Nate Hagens (00:37:51):

I read a Conoco PowerPoint a couple weeks ago that said that there's 3% or 4% flexibility currently like that, but it's not 30% or 40%.

Joris van der Schot (00:38:04):

No, you're right, this is on the margin. And then, with a little bit more time... sorry, there's a possibility also for different uses, of course. So, in Europe for example, we send molecules to the chemical industry that in the US might go into gasoline. So, you can just route things to different uses, but of course you have to have the use for it. But on the medium term, I think if you reduce the gasoline demand fairly intensely, refineries will start adapting and will use their flexibility and on the 10-year term, they will be able to invest in units that just make different products that are more suited to your new situation. So, over time, the refineries can adapt.

Nate Hagens (00:39:02):

But we would still need diesel and bitumen for roads and naphtha for plastic precursors and all those other products unless demand for those products goes away as well.

Joris van der Schot (00:39:18):

Oh, yeah, sure. But in the end, it's a mass balance thing. If you have less demand, even if it's just on one of your products, in the end, you're going to need less crude oil.

Nate Hagens (00:39:31):

I don't know the situation in Europe, but in the United States, they're not building any new refineries. And I know that the majority of our crude is shale oil, light oil, and we have to pair it with our existing refineries with heavier oil from somewhere else to get the portfolio of atoms or of molecules that you just described. Is that a risk to the global refining industry as the world has more geopolitical instability and different existing built infrastructure refineries require a certain caliber of oil, or how much can we MacGyver the existing refineries to adapt to a narrower portfolio of inputs to their refinery?

Joris van der Schot (00:40:32):

I think we have quite some flexibility, but overall, I'd expect, or at least in Europe, we've seen refinery closures. So, the smaller ones and the simpler refineries that have less upgrading capacity will close first because they're the ones that make the least money. And the larger ones are able to mix, as you just described, maybe a very heavy crude and pair it with a very light one. And you just make a 50/50 mix so that you have your distillation column nicely balanced and all your subsequent units. So, you can do quite a lot. I think if you're talking about more and more high sulfur crudes, for example, it needs investment in desulfurization capacity.

(00:41:23):

So, you may see an ongoing need for investment in these assets so that they can treat the increasingly difficult crude oil because I think the stuff we're getting out of the ground, especially in the states, becomes more and more complex. And this is why for tar sands, for example, the overall CO_2 impact is also a bit higher than for regular crude because it's so much more difficult to refine and upgrade.

Nate Hagens (00:41:53):

So, what about, and just feel free to tell me if this is a question you don't have expertise in, but there is the chemistry of scaling and overbuilding solar, wind and other renewable technologies combined with hydrolysis to create zero carbon or low carbon fossil fuels. Like we can create some of these chemical chains with technology at a higher cost. What can we do and what can't we do and what are the trade-offs in that?

Joris van der Schot (00:42:36):

Yeah. I'm not the best expert to ask, but on a conceptual level, there is carbon around and you can shape that and create your own molecules, but it's going to take you a lot of energy and equipment to do that. I've seen some schemes to pull carbon out of the air, for example. That doesn't sound very efficient to me. It seems crazy, to be honest to me, to build machines to get the CO2 out of the atmosphere, given the concentration levels in the atmosphere, right?

Nate Hagens (00:43:22):

You're going to burn a lot more carbon with the energy that you use in order to do that. I have not seen one of those schemes that works. And unfortunately some of the IPCC scenarios fully build in developed global technology that pulls carbon out of the air that way.

Joris van der Schot (00:43:43):

If you're talking reducing carbon levels like that, the only thing that makes sense to me but it's more of an intuition than I've done any sums, is to use nature. A tree pulls carbon from the air, so plant trees or maybe some of the more, let's say novel things to stimulate algae growth in the oceans or something like that. But I'm sure that has its downsides as well. But nature can do things for us like that. I think there's some people looking at enhanced rock weathering, but building machines to pull out carbon doesn't sound very promising to me.

Nate Hagens (00:44:33):

So, what does sound promising to you in your history at an oil refinery and what do you think about our future on energy depletion, climate change technology? What are you thinking?

Joris van der Schot (00:44:56):

I think in scenarios, and I think there's one scenario which is by far the most likely one is that we're going to transition away from using this solar capital that we have in the ground to using solar income in the form of photovoltaic wind farms and the likes. I don't think that will be overnight at all. So, I'm not very optimistic about the speed at which we can actually transition because the investment you need to do, or the results are linear with the investment that you have to do. Sometimes, people say, "Oh yeah, it's all going to be exponential," and they cite the equivalence of the microchip revolution.

(00:46:04):

But I think the big difference with that type of exponential growth in the microchips was actually that it was an exponential shrinkage. They just managed to edge more and more circuits into a fixed amount of material. Whereas if you want to grow solar, PV exponentially, it means you just have to cover more and more square meters or square feet or whatever you call it. And I think that is going to take a lot of time and time we may not have.

Nate Hagens (00:46:47):

But even that isn't an energy transition. It's an energy addition to the global superorganism, which is totally dependent on hydrocarbons. It's more like building a protuberance on the body of the superorganism that might end up as a fin or a wing or something, but it's not replacing the whole body. Do you think-

Joris van der Schot (00:47:11):

No, for the moment we aren't. You're right. For the moment, it's only additive. So, we're maybe avoiding, we've avoided further growth, but for the moment, fossil fuels are still growing. And so, that's a real issue. The underlying issue is of course, that, from energy concentration perspective, we're going back to being hunter-gatherers, right? We're chasing the wind and the photons that you have to catch with these giant nets we call PV panels, or these blades we call wind turbines.

Nate Hagens (00:47:53):

Well, I think you said it aptly earlier, is we're trying to shift from using solar capital, our stored sunlight bank account, to living on solar interest, which is the daily, weekly, monthly flows of the sun and the wind plus technology. So, usually, when people start living on interest instead of drawing down capital, they have to consume less. So, I don't see a way that we can have a 19 or 20 terawatt society with renewables not even close. But I do think in tandem with declining oil and gas and hopefully not much coal with solar like you point out, there is some intermediate landing point for society.

(00:48:45):

Have you done the numbers on that or do you have any opinions on the size or how that might look like?

Joris van der Schot (00:48:51):

No, I haven't done the numbers, but I've seen different scenarios of... I don't think there are many scenarios that see this 20 terawatt going up, but there is a lot of room-

Nate Hagens (00:49:05):

Other than the IMF and the World Bank and the United Nations and most of the international authorities.

Joris van der Schot (00:49:13):

Yeah. We'll see about that. But I think there's a lot of room in efficiency though, because the 20 terawatt is primary energy and you don't have to replace about... I don't know, 40% of that is just waste heat. And so, you don't have to replace the waste heat, of course, when you install your solar panels and your wind farms.

Nate Hagens (00:49:40):

So, what ends up happening is if we stabilize and somehow are able to keep the financial system intact, is turning a larger percentage of our machines to motors that are more efficient. It is a reverse Jevons paradox that on the flat to down slope, that efficiency will soften the blow if more of our machines are electric as opposed to wasting most of the energy just to move a 3000 pound vehicle powered by gasoline or diesel.

Joris van der Schot (00:50:21):

Well, yeah, it should be a combination of a lot of things. So, the switch to electric for vehicles is part of the answer. I'm Dutch, so I think we should cycle more where possible.

Nate Hagens (00:50:41):

I'm Dutch too, and I cycle every day.

Joris van der Schot (00:50:42):

And so are you, good. A lot of our movements are luxury movements. Let's face it. I see it everywhere. We drive our kids to school. It's just crazy when you think about it. So, I think there's a case for more simplification and also smarter use of heating. Heat is a big part of the equation, and I think for a house through smart design, you can really bring down the amount of calories that you need to keep a comfortable temperature in your house.

Nate Hagens (00:51:25):

To totally put you on the spot, Joris, if you were advising the EU on energy policy, given what you know with your refinery background, and obviously you follow this podcast and are fluent in these systemic issues, what are some of the things that you think the EU and the world are doing now in the energy space that are likely dead ends? And what are some things that should be expanded and looked into and what are some other possibilities that should be researched even if they're not on the radar right now?

Joris van der Schot (00:52:00):

Look, I don't have a strong opinion on what the EU is or isn't doing at the moment. I think there's a lot of professionals in the fields that see the future, and sometimes there may be a bit of hype around this or that. But I think we should try a lot of things and also see what works. You don't always know from the start which technology, for example, is going to work. I think it's well possible that there may be a lot of advances, for example, in energy storage technology still, where you might say well, yeah, the lithium and the this and the that, actually contrary to the PV panels where I see this linear relationship between if you want more power, you have to install more square meters.

(00:52:48):

I'm not sure we've hit the bottom yet with energy storage technologies, and maybe we will find novel chemistries that are much less of an issue in terms of resources and that could really give us a performance boost. So, I'm pretty sure that there's a lot of upside in that.

Nate Hagens (00:53:11):

Well, there are things that are more simple chemistries like sodium batteries that aren't as good as lithium batteries, but are still pretty good. And salt is eminently more available than lithium.

Joris van der Schot (00:53:25):

Yeah, for example, and I think there's multitude of examples. I hear in the states, there's this startup storing energy with rust, right? Just iron rust. And yeah, it's not as compact as other batteries. It maybe takes up 10 times more volume, but if it's based on iron and it's for a grid-scale battery, maybe that's a good solution. So, I think there's a lot of room for innovation on that particular front still. Nor do I think that batteries are the only solution to energy storage, by the way, especially in my current role because we also see a lot of room in terms of managing flexible energy demand with the end customers.

(00:54:18):

I think historically, industries have always flocked around places where in space and in time, energy was concentrated, and that's fairly cheap. And maybe we've had this period where we could freely ship energy and have it on demand all the time, but it may not be all that bad to go back to the old days. So, where I live in the Alps, there used to be a lot of aluminum smelters, and you think, "Well, why in the Alps?" It's because there was hydroelectricity, right? So, they just installed the industry where the energy was.

(00:54:58):

And it was the same thing in 17th century Netherlands where we had this peat which virtually nobody had, at least not available at water level. So, it's easily transported by boat. And this gave a significant energy advantage to the Netherlands and so to the Dutch economy. I think half of the world's sugar refineries were in Holland at the time just because energy was cheap there. And that's the reason why Iceland is attracting heavy industries.

(00:55:31):

And maybe we'll go back to something like that where we concentrate industries not only where the energy is, but also when the energy is, i.e. when the sun is shining or when the wind is blowing.

Nate Hagens (00:55:44):

Well, that would mean that Switzerland and surrounding areas could be one of the richest areas in a post fossil fuel era, a century from now or whatever, because you have that height differential and can store water and release it whenever you want, natural batteries.

Joris van der Schot (00:56:09):

But look, I was looking at the electricity prices in Norway last week, and they've virtually been at zero, and Finland, by the way. They've virtually been zero because apparently it's rained a lot and all the dams are very, very full and they just have to produce. So, indeed, yeah, specific areas will have definite benefits. I think Canada has a lot of hydro as well, so could be developed.

Nate Hagens (00:56:39):

I want to ask you a few personal questions and you listen to my podcast. So, you know what I'm going to ask you. What advice do you have, being a macro observer, being non-energy blind? Do you have any personal advice to listeners at this moment of human predicament and global polycrisis?

Joris van der Schot (00:57:07):

Yeah, read your book.

Nate Hagens (00:57:11):

Reality Blind.

Joris van der Schot (00:57:12):

Yeah.

Nate Hagens (00:57:13):

Oh, you read that, huh?

Joris van der Schot (00:57:15):

I think nobody knows about your book, to be honest. Your podcasts are fairly well known. But it was a real discovery for me and it was an amazing thing because apart from being pretty new for me and I learned some things that I just never thought about, but it's also a hilarious. And so, my kids would see me laughing out loud on the couch, literally, because of the way you structured with your co-author.

Nate Hagens (00:57:48):

Yeah, My co-author. Most of the funny parts were DJ's.

Joris van der Schot (00:57:51):

Well, you guys have done a fantastic job. So, I'd recommend anybody who's remotely interested and if you want to have a good time, that's a good book.

Nate Hagens (00:58:03):

Thank you. Anything else?

Joris van der Schot (00:58:07):

No, that's it for me.

Nate Hagens (00:58:09):

And what about young humans? What recommendations do you have for teenagers and 20 somethings who are coming of age at this moment of the carbon pulse?

Joris van der Schot (00:58:26):

Yeah. Well, you can probably note I'm not much into saying people how to behave, but I'm again going to recommend reading 80000hours.org. And it's a wonderful website that sets itself the goal to find out you've got 80,000 hours in your career, how can you do the most good in the world? And I think that's a fantastic question to ask. And these kids, there's some young people from, I think it started at Oxford University, have just fleshed it out and said, "Well, what's the way to think about it, about your career choices and what you want to do and how you want to contribute to society?" And of course, there's a lot of thinking about contributing to environmental causes, et cetera. So, I'd recommend anybody to check that out.

Nate Hagens (00:59:24):

I have not heard of that or seen it. I think it's a great idea. I think education is first and foremost, and I think asking questions rather than having answers is the way to go. I will check that out and we'll put it in the show notes. Joris, what do you care most about in the world?

Joris van der Schot (00:59:48):

How many answers can I give?

Nate Hagens (00:59:51):

As many as you want.

Joris van der Schot (00:59:55):

I think we humans, we care about things we spend time on and we probably spend time on things we care about. It's like a feedback loop. There you go. So, obviously, your family and friends, but at a macro level, I think I feel a very close connection with nature as in just life other than humans. I mean, I like humans as well, but I think we're underappreciating the rest of the biosphere. And yeah, I care about maintaining a livable planet and about conserving nature, I suppose.

Nate Hagens (01:00:42):

I know that you are working on some very interesting things. I'll give you a chance to maybe give a teaser of that. But if you were to come back on the podcast, what is something relevant to our futures that you're passionate about that we could take a deep dive on?

Joris van der Schot (01:01:02):

Helio mimicry emulating the sun.

Nate Hagens (01:01:07):

So, when you say helio mimicry, are you talking directly about nuclear fusion or are you thinking other things?

Joris van der Schot (01:01:16):

Yeah. That's the reason I coined this new term is I think it's wider than the types of fusion that people generally consider. Most of the work today is done on what I'd call high energy fusion. You've got to make things really hot or very high pressure with lasers or with millions of degrees like they do in the South of France. And then, there's a range of startups that tries to do the same thing but more agile and smarter. So, there are billions flowing into startups all in the high energy fusion part. And the part that I actually am most interested in is the low energy fusion, also known as cold fusion. And this is much more uncertain, right?

(01:02:15):

There may only be a percentage chance that it actually works, but it's a risk-reward thing. And that's why I find it so interesting is if that type of fusion works, you may be able to get on a cost curve much earlier and much lower because those are compact devices that you could do fusion in. Whereas the other ones, you're just creating new nuclear power plants, so to speak, that are going to take decades and billions of dollars to develop.

(01:02:47):

And so, yeah, I'm actually quite interested in really testing the edges of science to see if there's a mechanism to do fusion at low energy. And that's not very common, but it happens to be the field that I've investigated over the past decade.

Nate Hagens (01:03:07):

And you say there's a percentage chance, as in 1% chance in that ballpark of this happening?

Joris van der Schot (01:03:14):

Yeah, that's my view. And the reason for that is that there are so many results coming in. Now, there's a problem with repeatability, reproducibility, but there's a research group at MIT. You've published about this, and they compare it to the transistor development in the 1930s and 1940s. In the beginning, we saw effects of the transistor type that we couldn't place. We didn't understand what was actually going on, and that took decades. And it was only when we actually understood the mechanism that we could develop the transistor, and that gave the microchip industry. I think something similar may be going on with all the cold fusion initiatives.

(01:04:07):

And this is why, for example, Google put 10 million into it a couple of years back. They didn't find anything, but it was a good science. They published in Nature about it. I think there's possibility that one of these groups will break through, and of course there's also an overwhelming possibility that they won't, but it's worth looking for.

Nate Hagens (01:04:33):

I have two general replies to that. One is most of the titans in AI believe that AI will solve the helio mimicry challenge. I think 100 terawatt society would destroy the earth and pull in so many non-carbon aspects of our natural world that there would be nothing left unless that technology was matched with social and governance innovations as well as the technological innovation. That's my general sense on that.

Joris van der Schot (01:05:14):

Look, I think you're right. At the same time, it's something that could really help us. But on the other hand, we have to get a lot smarter about how not to ruin the planet further. And if we get more powerful only to speed up our plundering of the planet, that may not be the best outcome for man. But in the meantime, if something like that can really help us speed up an energy transition, so for that, it would have to happen soon. That might be of interest.

Nate Hagens (01:05:50):

So, if I have a nuclear fusion reality roundtable or something, would you like to join in on that? Do you have enough insights and ideas?

Joris van der Schot (01:06:01):

Yeah, sure.

Nate Hagens (01:06:02):

Okay. We'll do it. Joris, thanks so much for your time and for reaching out to me a couple of years ago, and to be continued, mon amie.

Joris van der Schot (01:06:14):

All right. Thanks, Nate.

Nate Hagens (01:06:16):

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