The Great Simplification

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Pedro Prieto (00:00):

It was a complete blackout. Close to 60 million people were out of service. Hospitals, they had to stop operations and supermarkets, they cannot serve, they cannot count, they cannot invoice. I mean, the telecom network is very important, but the traffic was so heavy when the people were blackout, we could not communicate with each other. We were very badly prepared because we are very confident that our network will never stop. People do not realize that it may happen so fast.

Nate Hagens (00:31):

Joining me today is my friend Pedro Prieto from Madrid, Spain to discuss the power outage in the Iberian Peninsula that happened on April 29th. Pedro is the vice president of the Association for the Study of Energy Resources, which is an open space for debate and communications on energy issues and the role in demography development, economy, and ecology. Since 2004, Pedro has led several solar voltaic projects in Spain, as well as written numerous articles, co-authored a book with Charlie Hall called Spain's Photovoltaic Revolution: The Energy Return on Investment, that challenged the conventional boundaries of energy analysis that are used in systemic calculations.

(01:29):

Pedro has been a friend of mine for 20 years and I called him up to see if he could share what happened during this blackout. Why did it happen? How might we think about it going forward and the implications for society? Please welcome Pedro Prieto.

(01:47):

Pedro Prieto, saludos amigo. Welcome to the show.

Pedro Prieto (01:51):

Saludos. Thank you very much.

Nate Hagens (01:53):

You were on this show before on a reality roundtable maybe two years ago on electric vehicles. I am blessed to have some good friends in the country of Spain. You are foremost among them. Earlier this week there was a blackout which we're reading about in the United States. What happened? Give us a broad overview.

Pedro Prieto (02:15):

Well it's difficult to know yet what really happened because there are many factors that may have influence, but what happens basically is that about midday, which is exactly the moment where we have higher insulation, then about 12:30, something like that, and it was a complete blackout. The recovery, it lasted for between six and 24 hours depending on the part of the country and everything went mad. I mean, everybody was in hell and many people were disturbed and they are still trying to analyze what happened.

(02:57):

Fortunately for such a complex country, we are 48 million now and Portugal has 11, it's close to 60 million people were out of service. A small part of south in France also was affected, but I mean France immediately switched off the connections and they stabilized their network without any problem. But we needed several hours and now we are about 99.9%, but not yet even 100%. Some things have changed. We have seven nuclear reactors and there were about four out of service. Not out of service, but they had been previously disconnected few days ago. One for maintenance and for replacing the fuel rods and the other three, they were disconnected because excess capacity because this is the period of the year in which we consume less. There is no central heating expenses. There are no [inaudible 00:04:02] expenses yet. So the consumption was minimum. It was within 25, 27 gigawatts national consumption and what happened is that we went down completely.

(04:21):

I mean, everybody's very nervous trying to put their responsibility on the others. This is what happens. These days I remember very much the phrase of Upton Sinclair when he said, "It is difficult to get a man to understand something when his salary depends on him not understanding it." This is what is happening now. I mean the ministry is trying to say that they were the operators. The operators, they say they were complying with the regulations. Some other people say it's the excess of renewables,

that they could not manage to balance the excess of inputs with respect to the consumption. I mean there are still many speculations. But the fact is that some others they say that it was over 500 megawatts solar photovoltaic plant in the southern part of Spain which went down suddenly and they could not recover immediately. In that moment, we were exporting energy to France, to Portugal, and to Morocco and then suddenly we went off and this is what happens until now.

Nate Hagens (05:29):

So what was it like? Maybe you could give an overview of, you were in Madrid at the time where you live. What was it like during those six, seven hours and what kind of stories did you hear and is there anything that you heard that we might not be aware of here in the United States?

Pedro Prieto (05:48):

Yes. Of course. Probably in the United States as you are a customer, even you have had, I understand, blackouts in New York and some areas of New York that probably, as far as I remember, there were two, three days to recover in some cases, but interesting things happened, I mean, that people do not realize that it may happen so fast. I mean like for instance, in a fully electrified home like mine, I could not serve myself a coffee because everything is electric. So I could not heat. I should have had some gasoline there to heat something in a small kitchen or something like that, but people was not able even to cook. I mean the lifts were blocked in the big apartment blocks-

Nate Hagens (06:28):

The elevators.

Pedro Prieto (06:29):

Yeah. Thousands of people were blocking the lifts and there were no backup energy to move them in the hotels or something like that. I mean sometimes I notice that some underdeveloped countries or countries less developed are sometimes better prepared for blackouts than ourselves. For instance, I've lived in Brazil and I've seen that brownouts or blackouts are frequent, but I mean almost every apartment block has a backup with a generator that jumps automatically when there is a blackout. So they

still can manage with the lifts or they still can manage with a minimum energy supply, electricity supply, to the homes or something like that. But not in this case.

(07:10):

So we were very badly prepared because we are very confident that our network will never stop. I mean hospitals, they had a problem. Hospitals, they have backup, but not for every, I mean they had to stop operations and the surgery of many normal and conventional operations, they could not transport some of the patients from the floors they were to make some scanners or radiographies or whatever. I mean, the telecom network is very important because what happened is also, I mean in theory, I come from the telecommunication world. When we designed the networks, we designed them for at least six hours backup so that you can still keep calling people and something like that.

(08:03):

The same for the bases stations of the cellular network. And they were working, but the traffic was so heavy when the people were blackout that they decided to shut, I mean, and to cut all the video conferences and then they started with the audio conferences and then they moved to the text and then finally, not even the text. In my personal case, for instance in my home, I was having the signals that I was a bases station connected, but in four hours, not in six, but in four hours, it was disconnected as well. So we could not communicate with each other. And then we have a problem in our country, and I suppose that also in the United States, is that we are accustomed to the immediate responses. I mean, we are people very anxious and if you want to know what is happening to your brother or to family or a friend or whatever, you try to connect immediately. And if you cannot, you even hyperventilate.

(09:03):

I mean the people started to be very nervous at the beginning. Contrary to what it may happen, this is a very social country. I mean people socialize very much. So what happens is that people went out to the streets and they discovered that they have neighbors that normally they don't get in relation with usually. Supermarkets could not serve because they are so specialized that they are reading barcodes and something like that automatically. So there are very little cashiers for so many people. So when the lights are off and there is no electricity, they cannot serve, they cannot count, they cannot invoice.

Nate Hagens (09:41):

And the credit cards wouldn't work.

Pedro Prieto (09:43):

The credit cards didn't work neither because they depend on the network. It's interesting because in the past, all the telecom systems were copper cable, from the subscriber to the public streets, they were copper cable. And that means that when the electricity in a city or in a country went off, so you still had six hours in theory to communicate and to have connections, electrical connection. But now, everything is optical fiber. So on the sets, the telephone sets and the mobiles and [inaudible 00:10:17] mobiles, they have their own battery, but telephone sets, the fixed telephone sets, they don't have battery. And I mean if you try to make a fixed telephone call, it doesn't work neither because they depend on the mains of the home.

(10:35):

So it was supermarkets emptied, city gas, even the city gas and the water, you know that when there is no electricity, most of the cities, you do not get water by gravity in most of the city. So you still have the pressure in the pipes. But if everybody starts using water because they are afraid of what is going to happen, then the pressure of the system is going down and you get without water if you are not hurrying in getting water. The same for the natural gas which is sent by pipe.

Nate Hagens (11:14):

So the takeaway message from what you just described is we are incredibly, naively, fully dependent on electricity in cities.

Pedro Prieto (11:26):

That's it. It's very naive. And payments and petrol stations that doesn't work. I mean the people stopped working in the offices and they say, "Well if the," and the first rumors were, when some mobile cellular phones were still working, they say, "Oh, there is a problem in Spain." Even there were rumors that there is a problem in all Europe. Fortunately it was not in all Europe because if it is in all Europe, the problem, it may have taken days or even a week or several weeks to recover.

(11:59):

So I don't know, but it's a very complex issue. So the people went out of the offices back home and then the traffic lights didn't work. So the traffic jams were horrible, horrible. I mean we have two rings in the city of Madrid and in Barcelona also and the first ring was blocked, then the second outer ring was blocked, and the people were blocked, completely blocked. That was incredible.

Nate Hagens (12:25):

We're recording this on Thursday, May 1st. This happened three days ago. In the United States when we read the news about this, there were a lot of pictures of people just using their phones to have olives and beer at a diner, but I imagine this was a traumatic event for a lot of people. Are things totally back to normal or are people worried or what's the mood?

Pedro Prieto (12:56):

Many people, initially they started to be worried and I don't know why. I mean in your frankly programs and as experts in energy, we know that this may happen, but many people doesn't know that this may happen at any moment. So at the beginning they were very worried, but then when they went out to the streets and they start talking to each other in a good day, in a good spring day, sunny day, or something like that, with bars open, even they could not serve many things. And so they ended saying, "Okay. Let's sit, have a beer, and have a tapas and let's enjoy and see what happens." And that's all.

(13:37):

So the city were full of people walking around and people even started enjoying the situation, the new situation, because they saw life in the city. Normally they are not concerned about the life of the others. I mean they run each other from home to the work and vice versa and stuff like that, but this, they enjoy it very much.

Nate Hagens (14:00):

It's a high standard deviation learning event because I'm sure there was a lot of positives and a lot of negatives and a lot of things that people are learning from. I actually think because of this, it's less likely that this is going to happen in Spain in the near term because the people in charge and the regulators are going to make

sure that there's a spinning reserve and cold start ability and backup however they have to do it, but as we both know, that has a price and that is higher cost.

(14:33):

So in addition to being my friend, you have two other credentials for being able to speak to this topic. One is you wrote a book on EROI and solar voltaic and energy systems almost 15 years ago, kind of predicting that this would be one possible outcome of overly scaling intermittent energy technology. And the other is that you actually lived in Iraq during some blackouts. So I'd like to lean on your expertise on both of those situations. Let's start with the renewable issue. Why did this happen? What are the general reasons that we do know and what's left uncertain at this point?

Pedro Prieto (15:28):

There is nothing definitive yet, but what is certain is that we have one of the biggest penetrations of renewable energies in the world. In solar photovoltaics we have, I mean the total network has 130 gigawatts of installed power. I mean this is just to give you an idea, we are in the size of California for US viewers. I mean the size of California in inhabitants, the size of California in space, and the size of California in energy and electricity consumption.

(16:03):

But we have a lot of renewals, as in California as well. This represents 65% of the total national capacity of installed power. However, when we consume now, we are consuming only the maximum peak. I mean when the blackout happened, we were consuming just 25, 27 gigawatts. So we have much more capacity. We never reached the peak. The maximum peak in 2024 in consumption was about 40 and we have 130 gigawatts installed.

Nate Hagens (16:35):

Okay. So the most demand ever last year of the 130 of potential was 40.

Pedro Prieto (16:41):

Yeah.

Nate Hagens (16:42):

And earlier this week we reached 23, which is only half of the-

Pedro Prieto (16:46):

That's it.

Nate Hagens (16:46):

Maximum.

Pedro Prieto (16:46):

That's it.

Nate Hagens (16:48):

So why was there, of course we don't have definitive, but how much of the energy was from the renewables of that 23 when it went down?

Pedro Prieto (16:58):

If you add up solar photovoltaic and wind, it was about 70%. 70, 75%. So it's a lot. It's a lot. And then the problem is that they are, as you know, intermittent energies. I mean they talk also hydro as renewable energy and it's a renewable energy, but the difference with solar and wind is that hydro is not intermittent. It's predictable. It's a predictable-

Nate Hagens (17:27):

It's like a combined cycle natural gas plant kind of.

Pedro Prieto (17:29):

That's it.

Nate Hagens (17:30):

You can turn it on and off when you need it.

Pedro Prieto (17:31):

They are much prepared to be smooth, reliable, and supporting the whole system. I mean they have a local-

Nate Hagens (17:39):

As long as there's rain.

Pedro Prieto (17:41):

Yeah, that's it. [inaudible 00:17:42] And this year we have had a lot of rain in Spain. All the dams were full and they were able to turbine and to generate electricity as much as they have in the installed power. So they were not installing there. I mean they were not generating the maximum, but there was a lot of renewable energy and there was a lot of intermittent energy given to the network. So that's why we were exporting to the three countries with which we have interconnections, international connections. And this is what happens. I mean something has happened that has unbalanced the network.

(18:16):

And the problem of the networks is that we need a very tiny deviation in frequency or in voltage to have a huge problem. Like a Houston, we have a problem. We are working here in 50 hertz or 50 cycles per second. In the US you are in 60, but here in 50, in all Europe, we have 50 cycles per second. If you deviate plus minus 0.1%, this is a problem. If you deviate plus minus 0.2%, this is a big problem and the system starts warning what happens. If it is plus minus 0.3%, then you have to switch off many, many elements for security reasons. Among them, nuclear power plants.

Nate Hagens (19:03):

What does that mean, cycles per second? Explain to us how that works.

Pedro Prieto (19:07):

The electricity is given in alternate form. I mean it's not direct current, it's alternate current. And 50 cycles means that the alternate goes from positive to negative in a cycle, in synodal, cycle.

Nate Hagens (19:23):

Yeah. A wave form. Yeah.

Pedro Prieto (19:24):

50 times in a second.

Nate Hagens (19:25):

Okay.

Pedro Prieto (19:25):

So if this frequency changes from 50 to 49.95, then we have a big problem.

Nate Hagens (19:34):

And was it a decision to shut it down or the 49.85 variation actually caused something physical to-

Pedro Prieto (19:45):

Many systems are automatically programmed to defend themselves because if they deviate in frequency and they deviate in voltage or something drops simultaneously because other source is prepared to, I mean it's generating more than they can drop and it's giving energy more than it can deliver to the network, it could explode. It could have a problem. So they are prepared to disconnect themselves.

Nate Hagens (20:10):

It literally could explode?

Pedro Prieto (20:12):

Yes, of course. Very heavy systems, they may explode when they have a lot of inertia and they have machines that, I mean they have motors engines, that they may weigh tens of tons and this is a huge weight turning very fast in the power plants. And then if something happens and they cannot control it, it could burn, even the high power cables could burn. So that's why they are so well protected.

Nate Hagens (20:41):

So what would have happened, just hypothetically, at that moment when there was 27 gigawatts of demand in the country of Spain, that there was a mandate or a requirement that 50% of that had to be from stored hydro or combined cycle natural gas plants, that there was a reserve that was easily dispatchable turned on and

turned off as a stabilizer, would that have minimized the risk of what happened or was that irrelevant?

Pedro Prieto (21:17):

No. It's neither irrelevant, but the situation is that combined cycle or nuclear or even hydro, they are synchronous systems and they have a lot of inertia. So they tend not to deviate. I mean if they feel a small deviation in the system, they will make whatever is possible to force themselves to keep the 50-

Nate Hagens (21:41):

Oh, so if all the renewables were supposed to be at 50, but they dipped to 49.85, the natural gas or the nuclear or hydro can quickly go to 50.015 to offset it instantly.

Pedro Prieto (21:57):

That's the difference. I mean I was talking with Antonio [inaudible 00:22:02], you know that because he has been in [inaudible 00:22:03], he said something quite clear. I mean the inverters of the renewable system are mainly of photovoltaic type systems because wind is operating in a slightly different form, but renewables in photovoltaic systems, the inverter, which is changing the direct current they are generating from the solar modules and giving alternate current at 50 hertz to the network and they are injected into the network. So they have a system to accommodate and to synchronize with the 50 hertz in exactly in the same position.

(22:39):

But they are so good that if the frequency changes, slightly changes, they adapt. Instead of rejecting, like the heavy synchronous equipments like hydro or nuclear or combined cycle, they resist any change from the 50 hertz. On the contrary, the inverters, when they see a small change, they immediately adapt to the small change and this could have added to the problem instead of solving the problem, instead of minimizing the problem.

Nate Hagens (23:11):

So instead of a balancing feedback or a negative feedback, it became a positive feedback or a reinforcing feedback?

Pedro Prieto (23:19):

Exactly. This is one of the possible reasons. I mean there are many other arguments. I mean the plant of more than 15 megawatts, the sudden fall, which they are still investigating, of 15 gigawatts from the network. I mean nobody knows who fell down at such level. I mean they are start analyzing now and it will take days because there are several thousand nodes in the Spanish peninsula and they have to analyze millisecond by millisecond what happened and who was first and why it was first or something like that. This is what they are analyzing at that moment.

(23:57):

So when everything went down and we have the blackout, the first thing after four, six hours that entered into the system and took reference from the links we had with Morocco and with France, there were still links and they could synchronize with Morocco and France thanks to these connections and they started to operate first with combined cycle and then with hydro. I mean it was basically in the first hours of the morning of April 29th, the main entrance into the network to reestablish the power in the country, it was due to mainly the combined cycle and to the hydro. Later on, renewables have entered and we still have at zero level the seven nuclear power reactors, which are the more complex and the ones that have to be treated much more carefully.

Nate Hagens (24:54):

Are those back online, the nuclear reactors, as of today Thursday, May 1st?

Pedro Prieto (25:01):

No. Not as far as I know. Not yet.

Nate Hagens (25:02):

Okay. So this gets into territory that you and I have covered deeply in our private conversations over the last 20 years. We are both pro-renewable, but with an asterisk. A, that when you add renewable energy to a system, you can't assume that adding 1% from a base of zero has the same benefits as adding from 60 to 61% of a system because the full system needs to be analyzed. And then yours and my and our friends and colleagues, broader point is we can't use renewable energy, solar and wind and

the like, to power a 19 terawatt system with our current massive consumption and, like you talked about earlier in Madrid, people just assume that there will never be a grid failure because they've built the lifts and the hospitals and the supermarkets and the cash stations and everything else assuming there will never be a blackout.

(26:09):

So let me ask you this. You operate a solar PV plant. And over the years, especially this year, you've told me that you have to pay the regulator or the government on a sunny day because there is so much solar PV electricity being fed into the grid that supply and demand market system, the prices go below zero. Can you explain that situation and why that's important?

Pedro Prieto (26:42):

Yeah. That's quite anomalous, but it's also another symptom, which is very important. I mean we have been receiving from the system, I'm going to receive, I mean the people that like me are operating a plant of one megawatt plant, which is very small, but one megawatt is important, we are receiving every day the prices, the wholesale prices, we will be paid the day next, hour by hour in the 24 hours of the day next day. So we can be prepared to know how much money are we going to earn. If you see the list of, the daily list, of this in the last three months for instance, you will see that most of the days, most of the days, the system is saying that they will pay you, and in not all the days, but especially the sunny days, they will pay you negative, which means that if you inject one megawatt hour in the network at 13 hours when the price is minus one euro per megawatt hour, then you will have to pay to the system one euro for each megawatt hour you inject into the network, which is something which is counterintuitive.

(28:00):

I mean it's something that people doesn't understand, but this implies that they have plenty of renewable energy now because this doesn't happen during the nights. In the nights, you can get even, I mean from minus one in the day, you can get up to 100 euros per megawatt hour that is consumed.

Nate Hagens (28:20):

So what power sources does Spain use in the nighttime mostly?

Pedro Prieto (28:26):

In the nighttime the base load, the main base load is nuclear.

Nate Hagens (28:29):

Except right now all the plants are down.

Pedro Prieto (28:31):

Yeah. Yeah. That's it. That's it.

Nate Hagens (28:34):

So what else?

Pedro Prieto (28:35):

So there is no combined cycle and there is a combined cycle. There are some others, like for instance, hydro. We have a lot of hydro now because all the dams are full. And then the consumption now is minimum now during the night it could go 20 gigawatts or even less than 20 gigawatts. They can cover it just with a combined cycle for instance, plus hydro. But they are making now. Now they are introducing now yesterday the president is a lady, the president of Red Electrica is the Spanish regulator, which is under criticism, very heavy criticism, but this is an organist which is one of the most advanced in managing renewable networks and renewable penetration in the world.

(29:21):

I mean they are very advanced, but they made a mistake. I mean somebody has made a mistake and they are assuming and they are investigating what has happened. And she said that now they could finally restore and introduce again back the renewables and they have introduced back renewables before the nuclear power plants. So to say that renewables are safe as well and they are not necessarily the main responsible, but the main responsible it may be the lack of backup of renewables because for instance, there is a very interesting indication. There is a magazine famous in Spain called [foreign language 00:30:00], Renewable Energies. This month, days before the blackout, they will say the last chip that still remains in the network. And the last piece is a full number dedicated to massive storage for the renewables. So that means that

they already knew that without massive storage for renewables, they may have a problem of reliability and they may have a problem of security.

Nate Hagens (30:33):

And didn't I read somewhere that you said that there's 130 gigawatts of installed capacity in Spain, but that there's another like 200 gigawatts or some huge amount, a number of proposed solar projects.

Pedro Prieto (30:47):

50.

Nate Hagens (30:47):

Is that right?

Pedro Prieto (30:47):

50 gigawatts.

Nate Hagens (30:48):

50. Okay.

Pedro Prieto (30:50):

50 gigawatts are still in the queue of promoters that they are still trying to inject into the network. This has already created a huge problem to the government because first they need to study carefully in which nodes they could inject that huge amount of energy. I mean, if we have 130 gigawatts, we are consuming average 28 and maximum 40. So that means that we have a lot of installed power that is idle most of the day. Among that, for instance, one of the problems we had is that almost all the combined cycle, gas fired plants, they were off, I mean not off even in pre-warming, they were off in cold off.

Nate Hagens (31:37):

So I also wrote about this 15 years ago. This was one of my chapters of my Ph.D. thesis is applying variability to energy returns. And when it's sunny and windy and everything is great, yes, but in these situations, you either need storage or battery or

some complimentary source, but if those complimentary sources can't make money, no one's going to build them and they're going to go out of business.

Pedro Prieto (32:05):

Yeah.

Nate Hagens (32:05):

So why would someone today decide to build a natural gas plant in Spain if they see all these renewables coming online? And if they did build it, how much would they have to charge to make money because half the time it's going to be idled, right?

Pedro Prieto (32:24):

I mean in fact, they have a big problem because most of the gas plants, they were installed when renewables were not so high. So they were leaving them aside. The more and more renewables enter into the systems, combined cycle, they were leaving aside. And now we found out that there were very, very little of them. I mean, I don't know whether I have four there or whatever is installed there in combined cycle, but they have about 50 gigawatts or something like that. So what happens is that they are losing money because they lose even more money when they had to keep them for a fast response in case of a fall.

(33:09):

In case of a fall, you can keep the plant in pre-warm situation, which means that you can, upon an order, you can put the gas plant, one gigawatts or whatever it is, into the system in minutes. But if it is in cold stop, then you may need four hours to pre-warm and then to get into the system. And this is what happens. I mean this curiously, it's a coincidence because when we had the blackout, it took minimum four to six hours to replace the system and it was because the combined cycle started entering gradually because they were the most reliable ones, but it took six hours to them.

Nate Hagens (33:49):

So if you had combined cycle plants either turned on or in the warm, not fully shut down, it might not have prevented this blackout, but the blackout would have been shorter. You would have gotten things back online sooner.

Pedro Prieto (34:06):

That's probably of course. If they had been in pre-warm, if they had been in pre-warm, but they were not.

Nate Hagens (34:13):

So how close were we to a much worse situation and maybe you could talk a little bit about your time when you worked as a telecom engineer in Baghdad, when there was a worse situation.

Pedro Prieto (34:29):

When the war starts between Iran and Iraq, first Iraq bombed Hormuzar and Abadan and Horran, two big refineries in the Persian Gulf, and then the Iranians, the day next, they started bombing power plants in Baghdad and in many other Iraqi cities. So we went blackout, completely blackout for three days, with the skies fully black of smoke from the fuel oil tanks of the petrol plants, I mean from the power plants. So when you start to be in a complete blackout, it is a disaster. I mean, the first priority for instance is to get water.

(35:13):

Then apparently the Iraqi government that had already been the one that planned the first attack on Iranians, they had already prepared, somehow they had prepared the situation and for instance, three months or one month after the war had started, we started to give energy electricity to several suburbs, perhaps two hours a day to one suburb then the other one another two hours or something like that. When you have two hours electricity in a country that is in blackout, the first thing is just to pump up water to the tanks in your terrace of your house because most of the houses in Baghdad, they were one or two stories. This is one.

(36:01):

Second, petrol stations don't work and then the queues in the petrol stations are huge. The people start becoming nervous. Then they are rationing all the plates and even plates one day each. So there is a rationing in the transport. Food, I mean the change [inaudible 00:36:20] of the food in the transport is deteriorated. So 60, 70% of the food system and channels, they arrive to the markets already rotten. So that because the war happened in September and in September there is 40 Celsius centigrade and

then there is a lot of hot and then most of the food was destroyed. And there were many other things that they were disturbing the normal life and it lasted for years.

(36:49):

I mean, I understand that still today in 2025, most of Iraqis are suffering brownouts from time to time. So it's a dramatic situation because nothing works. Nothing works. Well traffic lights in Madrid or in Spain, in Barcelona, whatever it is, generate a chaos because the people is accustomed that the traffic lights are working. In Baghdad they were not. So they were much flexible. When you arrive to a square or something like that, they were giving way each other slightly in a very crowded place, but they manage better than we manage.

Nate Hagens (37:27):

There's so many lessons here. I mean this whole, I wanted to talk to you just as a friend, about this half day blackout that happened, but really underpinning this conversation is the deep theme that you and I have been discussing for 20 years, which is energy blindness. We just don't see how we swim in a sea of energy services every day. And then another message is, having experience with brownouts and knowing how to deal with intermittent in your own life and the structures in your society is a blessing. It's a training. It's education. And western cities and cultures don't have that at all.

Pedro Prieto (38:16):

There are many people in the world that they are accustomed to that, but we, the Europeans and the United States, we are believing that this will never happen to us. And it's very simple for us to happen. I mean, if one day we run out of diesel or we have a problem for serving diesel, I mean, who is going to fill the supermarkets? I mean, in the big cities, in the big megacities. They're not thinking. I mean there are no gasoline or they are not electric heavy trucks.

Nate Hagens (38:45):

But we're unlikely to run out of diesel. What we're going to do is run out of the affordable quantities of diesel that we've become used to.

Pedro Prieto (38:54):

That's it. And then some Europeans and US countries, probably they could manage to still to be served, but many other countries that still have diesel today, they will start facing problems because they will eat and diesel did not arrive, will not arrive, and then they will have problems to make their normal lives and to find trucks taking essentials.

Nate Hagens (39:15):

So back to the blackout, what can be done? This may have been a big learning experience for Spain, for Europe, for everyone because of what you said. If it's likely that the little bit of variation between how many cycles per second, if that ends up being the reason why this happened, more backup batteries and such and/or a higher percentage of fully on or fully dispatchable combined cycle plants or nuclear or hydro, but what's the broader answer here, looking ahead decades?

Pedro Prieto (40:04):

That's a very good question for which I have no any definitive answer. I mean-

Nate Hagens (40:09):

But you have some expert speculation, so please.

Pedro Prieto (40:12):

Yeah. Okay. Well we can presume that, I mean I have made calculations, but it will be long to explain, of how much backup in batteries. I mean, we have two ways to store electricity in massive form, either pump up hydro. I mean we have a lower dam, an upper dam. So we pump the water from the lower. When there is excess of electricity, of renewables for instance, we pump up the water from the lower to the upper. So we convert kinetic into potential and then the potential we convert back when we need it, we convert back in kinetic by putting the turbines in movement.

(40:55):

So this is one way. But in Spain we have four gigawatts of store, I mean pump up hydro. This is too little. I mean, if we want to have 100% renewable electric world, this is very little. I mean for a country which is privileged in dams and in hydro, I mean in hydro we are a dry country, but we have a lot of dams because we have a mountainous country, mountainous. But it is not enough. The second one, it should be

batteries, but batteries are expensive. The most well-known batteries are lithium ion, I mean ion lithium batteries and they are very expensive.

(41:38):

What I want to ask people and to beg people is just to make calculations. I mean, do the math, as Tom Murphy used to say, do the math. I mean, don't trust the people, do the math. When you do the math, you realize that you need such an amount of lithium batteries that it will be brutally costly to have renewables. Now we are presuming, now in Spain many people from the renewable world [inaudible 00:42:04], they are saying, "We have the cheapest form of energy nowadays." But this is a trick because they are not calculating, they are excluding that from massive storage, from the required massive storage to make this system absolutely stable.

(42:23):

And this is what I was telling with Charlie Hall in the book in 2013 and nobody listened. Nobody listened. This is exactly what we need, a massive storage, but massive storage is brutally expensive. Brutally expensive today to cover the needs of a country like ours, which is ultra-consumerist.

Nate Hagens (42:42):

That dovetails with my work showing that, for most technological processes in our world, we're adding 1,000 or more units of fossil energy to the machines to do things that humans used to do manually or with draft labor. And we can do that and renewables can do a lot of that too, but the cost. If the cost double or triples, almost all of those benefits go away. So these processes in our world are incredibly sensitive to cost. So what was the example you used recently about a chariot and the horses?

Pedro Prieto (43:23):

Yeah. The chariot and the horses is that, before having installed all these photovoltaic plants or the wind power plants, we should have asked in parallel, "Why don't we put massive storage with them to give them stability and to avoid that the system could stabilize when we reach a certain level of penetration of renewables?" And they didn't do that because the government was only interested, the government and the promoters of course and the solar PV sellers or something like that, they were only interested in installing more and more and more without backup. And this is

something which is not rational, but this has happened not only in Spain, it has happened everywhere in the world.

(44:09):

I mean, they have installed and they have made the prices, I mean, when we calculated the EROI, I mean energy return on energy investing, they never, I mean even the most world recognized experts in EROI for photovoltaics, they always took out the massive storage as a cost of the renewables and this is a mistake. I mean, they have to be integrated and then see if it is worth the overall cost to make this source stable. Let's see if it is worth.

Nate Hagens (44:43):

So the focus was on the exciting new technology of the solar or whatever, which was the chariot, neglecting the fact that we need horses to pull the chariot, which is either complementary energy sources like natural gas at the same time or batteries or storage. And if you integrate all that, the full chariot and horses together, it's a different cost structure for society.

Pedro Prieto (45:11):

Yeah. That's it. It happens. I'll tell you a small story. We have been robbed, I mean, in our photovoltaic plant two weeks ago. They went in the night and they cut the cable, they cut the cable and they pull the cable because it's very heavy. There are thousands of kilos and they pull it from the underground ducts, they pull it with a tractor or with a four by four, I mean a SUV. They pull it and then they took it away and they sell it because the price of the copper now in the black market is between five and five euros per kilo, something like that. So in one night they took 2,000, 3,000 kilos and they stole it.

(45:57):

The second day, they stole it again, but they came from installing another photovoltaic plant. And in the four by four Nissan Patrol, they put some part of the stolen copper of the previous plant they have stolen and they put that and they were about 200 kilos in the backside of the Nissan Patrol. And as there have been rains, I mean the excess of greed of the robbers, made the Nissan Patrol to capsize and they

could not take the cables out of the plant. So they cut our cables, but they could not take up. So that's the problem of being so greedy.

Nate Hagens (46:41):

But it also is another small, maybe not small, problem with decentralized energy because they couldn't have cut the cables in a big natural gas plant probably because there would have been security and other things. You just had the cranes and maybe that giant bowl that roams around the forest in Extremadura.

Pedro Prieto (47:05):

Yeah. In any case, we had alarm systems and they didn't work. I mean, probably they have systems to inhibit the alarms.

Nate Hagens (47:17):

I mean, big picture, Pedro, when we look at our situation, I think once people remove their energy blinders and recognize how our modern lives, eight billion humans, not evenly distributed, but in total 119 terawatts continuously, which is 190 billion 100 watt light bulbs turned on 24/7, is unsustainable. And once you start to learn about it, you think, "Ah. Well fossil fuels are dirty. They are polluting the oceans and the biosphere and they are depleting." And the average decline rate in the world is probably 25 to 30%, which we're offsetting by new discoveries and some new technology, but it is a bank account that we're drawing down rapidly, but treating it as if it were interest.

(48:22):

So let's get some new alternative. Let's invent some complimentary technologies to give us energy. There's that conversation, which is assuming everything else stays constant, how do we change our supply? The other conversation is, do we really need all these energy services and all this stuff to live happy and healthy lives? Maybe we can, as Jean-Marc Jancovici would say, [foreign language 00:48:51], which in English would be restraint or sufficiency and actually reduce our demand. What are your thoughts on all this?

Pedro Prieto (49:02):

I think Jancovici is right and we have a problem ahead. Very, very big problem ahead because what happens now is that I would like to say that there is life with much more

sobriety, I mean sober people. I mean, we are now, as you very well know because we have been working with this data for years, you know that we are working like a machine, a 4,000 watts machine or 5,000 watts machine here in Spain, like-

Nate Hagens (49:32):

And 10,000 watts where I live.

Pedro Prieto (49:34):

10,000 watts in the United States. So we are 100 bulbs, incandescent bulbs on our head 24 hours a day. And this is too much. I mean, we don't need that. I mean, our metabolism is just one bulb of 100 watts. This is the physical metabolism. But now we cannot return so easily to these levels because we are naked apes and we cannot live in winter absolutely naked. So it's very difficult. I'm more-

Nate Hagens (50:01):

If you lived where I live absolutely naked in winter, you might not survive.

Pedro Prieto (50:05):

Yeah. That's it. That's it. But what happened, and as Tad says, our common friend Tad says, if you live in Saudi Arabia without air condition, probably you won't survive neither. So we have been accustomed to live in places by using a lot of energy. Can we use less? Easy for me because now I am retiring from Madrid and living in the countryside as you know and I can live with very little, I mean less than 2000 watts, probably 1000 watts. And I can have life with dignity in 1000 watts level, not in the 4,000 I'm now or in the 10,000 you are.

(50:43):

But the problem is that more than half of the society is all urban society. More than five billion people are now urban. They are-

Nate Hagens (50:51):

Urban.

Pedro Prieto (50:54):

They are urban and they have no place to go back to the countryside to go back and to live with water coming from springs without any pumps or something like that. I mean, it's not so easy to decrease in consumption when you have already built up a human construction, which is incredibly big. It's what you call the gigamachine or the thermos, how do you call it? The-

Nate Hagens (51:22):

The superorganism?

Pedro Prieto (51:25):

Superorganism.

Nate Hagens (51:26):

Yeah.

Pedro Prieto (51:26):

I mean, the superorganism is very difficult. It's going to be very difficult to take it back and to reduce our consumption. I mean, go out of the cities, go out of Sonoma.

Nate Hagens (51:39):

So while I have you my friend, what other advice do you have for the viewers of this program?

Pedro Prieto (51:45):

We are proposing the great simplification, but in fact, this is something we have not yet achieved. Not even me, not even myself, which I believe I am one of the most aware people about the problem coming, but still resist in a big city because I have family, friends, neighbors, relations, links, everything. I am tied up very much to the big city, but I'm trying, honestly. I mean, two of my sons are already quite well-prepared. I mean, there is nothing sure for anybody, but they are much better prepared to go outside to try to make a living in the countryside and with better natural resources and less material resources. That's my only proposition. I mean I cannot say anything else.

Nate Hagens (52:35):

So thank you for your continued interest and expertise on these matters. Just personally, it's reproaching 7:00 PM your time, what might you have for dinner tonight? I'm just going to live vicariously through your Spanish menu. Do you know what's for dinner, what Marisa's going to cook or-

Pedro Prieto (52:56):

No. We are going to a restaurant because my bylaws have come just from Brazil see how is life? They are energy [foreign language 00:53:06]. They come from Sao Paulo to Madrid. So we will meet with them at 2030 and we'll see what we have, but probably very little because we have had a good lunch today. So probably we'll go only to have some tapas and beer. That's all. This is what we'll have. In a sunny day like today, probably we'll do in [inaudible 00:53:35] in the open air and we will enjoy it, seeing people passing by.

Nate Hagens (53:40):

I've been to most countries in Europe, not most, but quite a few, and Spain is my favorite. I don't know why.

Pedro Prieto (53:49):

Thank you. Thank you very much.

Nate Hagens (53:49):

Yeah.

Pedro Prieto (53:51):

Probably because there is a very prosocial people.

Nate Hagens (53:52):

Yeah. That could be. And the food.

Pedro Prieto (53:54):

The food is-

Nate Hagens (53:55):

I have a lot of friends, but yeah. The prosocial people. Why is that and do you think that in itself is an advantage for what's ahead?

Pedro Prieto (54:05):

Probably because we were one of the countries that was later in Europe in developing from the technological and industrial first and technological way of life later. So I am very sad to see that our children, our young people, they are now totally stick to the cellulars and to the videos and to all these things. But I mean, 15 years ago, the children were playing in the street altogether. I mean neighbor with neighbor. And differently to your country, children are living out in the street without any problem usually. I mean, they don't have any problem. But the life is copying the United States here in Spain, not vice versa. And I think this is bad because in the United States, isolation of the individual is much bigger than here in Spain. We have here much more solidarity and much more intertwining among neighbors and friends and families and so on.

Nate Hagens (55:11):

Let's set up a roundtable on that topic, a couple other people from Spain, to talk about the social dynamics in Spain and how they're different than the United States. It's related to energy because it means that those are the things we care about most in life and we don't need all this extra energy for lighting and gadgets and novelty and such. So thank you for your continued energy insights and happy belated birthday and to be continued, my friend.

Pedro Prieto (55:45):

Thank you. Thank you to you and good luck with your programs-

Nate Hagens (55:49):

Everything.

Pedro Prieto (55:50):

Thank you.

Nate Hagens (55:51):

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