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EP 114 | An energy-fuelled debate: Are renewables actually becoming cheaper?

Disclaimer (00:25):

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Rob Campbell (00:40):

All right, it's a bit of the old and the new today on the podcast, in the sense that we're going to be talking about energy and power grids. Both older, more traditional sources, as well as renewables. But also in terms of participants: Justin, you are a wily veteran of the podcast and Mike, well, this is your first time on. So Mike Vogel, welcome!

Michael Vogel (01:00):

Thanks.

Rob Campbell (01:01):

Well, welcome to you too, Justin [laughs].

Justin Anderson (01:03):

It's good to be back with you again. I'm super excited to have this conversation with Michael and you.

Rob Campbell (01:08):

Well, I am too. And one of the reasons is that I've got a sense that you both aren't in complete agreement on all the areas that we're going to be talking through today, which is kind of cool. We'll get to hear some points of disagreement and some of the debate that we might have as a Research team at the firm. So, why are we here?

Mike, I'll start with you because a lot of it has to do with an observation that you had made recently in a team meeting that sparked a bit of a debate. So, wondering if you could just introduce the thought that you had that explains why we're here.

Michael Vogel (01:37):

Thanks Rob. So, the Research team was together and we were talking about big changes we're seeing across the world. And one thing that jumped out to me—I've followed renewable power for a while—there actually wasn't much new in renewable power by itself, but if you look at the prices of thermal, coal, and natural gas, they've shot up so high that all of a sudden the competitive scales between renewables and coal and gas just tilted so far towards renewables.

This raises the issue of maybe after 10 years of progress and higher efficiency products and [the] broader industrial ecosystem around renewables—maybe it really is the big tipping point now. Ironically, not due to the incremental success of renewable products, but just to this big price increase in coal and gas.

Rob Campbell (02:23):

Very topical for that reason as well. And maybe just to stick with you, Mike, you said you followed renewables for a little while. That's a bit of an understatement is it not?

Michael Vogel (02:31):

My very first job (this is a long time ago), I was making power converters for telecom equipment. So, if anyone is listening to this podcast on dial-up, it might be going through [laughs] some of the routers my stuff went into back then. And then mid-career, I was researching solar cells at Harvard. And what we were doing was working on surface effects of these solar cells to make sure the high energy electrons stay high energy when it's time for them to leave the cell.

I've been a fan of the products. I've been excited. I always knew the promise was there from the available resources, but it was tough over the years. When fracking came around it really brought down the price of natural gas, which brought down the price of power—which it looks like just created a big delay before renewables really had a chance to take over.

I'm speaking with a little bit of a North American tilt compared to the whole global adoption. Now, the one thing I'll certainly say, I mean this big spike in natural gas and coal, it might be short lived. Maybe this didn't happen because of a lack of abundance of these resources, it happened for other reasons. And maybe the prices do come back down and maybe this podcast looks very shortsighted by the time it reaches the listeners. But this is really a big change in the whole landscape.

Rob Campbell (03:37):

Interesting. On that, Justin, I'll go to you: on the landscape, maybe just sort of near-term—and Michael, would've talked about just some of the price increases in coal and natural gas—but maybe set the stage for us with respect to kind of the global energy context and either some recent history or broader history in terms of where we are today.

Justin Anderson (03:56):

For the listener, let's talk 30,000 feet. What are we using energy today for? There's sort of four rough categories that we look at when we think about energy consumption. One is transportation fuels. That's what everyone's probably most familiar with: oil to run our planes and our trains, cars, boats, all [those sorts] of things that move. So we use oil mostly for that and refine it and its different products.

Justin Anderson:

The other big use for oil is plastics and products. So, petrochemical businesses as feed stock for those. So that's one piece of our energy complex.

Then there's space heating, which is sometimes often kind of a forgotten cousin in the energy complex, but in Canada in January we're big fans of space heating because it's -40°C. And that's essentially burning natural gas or using electricity to generate heat so that you're not freezing your butt off.

And then finally there's electricity, which is really going to be, I think most of the focus that we're going to have today because it's really the topic that I think is what people are really focused on when it comes to energy transition. We could have separate podcasts on electric vehicles and the transportation fuels and what's going on there and there's some connective tissue there, but in the world of electricity is where we're seeing these very large estimates about how quickly we're going to transition from coals and nuclears and those types of technologies into renewable technologies.

So that's, I guess, the big picture stage that we're looking at.

Rob Campbell (05:16):

That's great high-level context. Yeah, I think we'll be focusing most of our time on the electricity power side of things.

What has that been looking like more recently? In terms of either demand changes or technological changes? Obviously climate considerations are playing into that as well. Or more recently, some geopolitics perhaps, in certain parts of the world. So what's that looking like more recently?

Justin Anderson (05:37):

Let me zoom in on the transition thesis as it relates to electricity. What's happening in electricity? Well, first of all, electric vehicles are growing like mad. We're seeing a lot of adoption of electric vehicles. They're popping up all over the street and that's going to fuel a conversion of some of—particularly our consumer fleets, passenger fleets, over from hydrocarbon-based to electric vehicles.

And if you look at the numbers and how that transitions long term, you might be looking at a tailwind for demand for electricity, kind of in the 2-3% per year for many years to come at the expense of say oil, which might be flat during that same period or maybe half a percent. So that's sort of the demand side of the equation, is that we're going to see robust demand for electricity. On top of that, global warming, climate change.

A lot of people, ourselves included, are worried about emitting too much carbon. We don't want to live in a world where we're causing damage to the environment. So there's a big amount of concern about producing energy but doing it without producing very much carbon. So that's top of mind. And then finally, as Mike alluded to, the costs of wind and solar are coming down and they're coming down dramatically. And so you kind of put the whole puzzle pieces together and you get to this analysis that says, well, obviously we're going to have this massive conversion from these hydrocarbon-heavy or these carbon-heavy sources towards these kind of renewable sources.

Justin Anderson:

And so I think that's really the transition thesis. If you look at some of the numbers that are out there, people are thinking that renewables might get to 50% of the total production of electricity by, say, 2050. I mean, estimates vary, but those are the kinds of numbers that are being floated out there. I think that's the core discussion that we want to tackle with today's discussion.

Rob Campbell (07:19):

Well, Mike, maybe going to you then just on the renewable side specifically—there are different types of sources, but can you dive a little bit deeper into some of the advancements that we've seen both in terms of the technology but also, I think ultimately, in terms of the economics?

Michael Vogel (07:32):

Yeah, that's right. So, the first thing I'll say is in the very recent past, kind of the last year or so, I'd argue that the commercial solar and wind products probably haven't improved all that much and there's probably even some price increases for the first time just having to do with general industrial inflation. The big success story of these massive price declines really happened sort of in the last decade from 2010 to 2020.

Let me talk particularly about solar. A solar cell is half of one transistor. So, this all spun out of the semiconductor industry that historically served consumer electronics and industrial electronics. When there was this big fork, there was a lot of optimization for solar cells that just never made sense to do in the electronics world. Simple stuff. The coatings of these silicon cells were suddenly etched with a certain material to make them rough, so there was less light reflection. So the light would stay trapped inside the cell.

There's no reason you would ever do that in the electronics industry, but once a little bit of scale picked up, these kind of improvements would happen. Things as simple as the glass that packages these solar panels—you need something strong enough that'll survive the elements outside, but it also has to be very transparent. And things like the glass suppliers weren't optimized yet. So what you saw from 2010 to 2020 was this very successful branch out of its own industrial path. And you saw a power output per square metre of these devices going up, seriously, about 50%. I'm not sure gains like that are going to even be possible for the next decade. We can talk about some potential ideas of stacking certain types of cells on top of each other to pick off different wavelengths of light. Even if that's successful, we maybe get another 20% out of these cells.

It's getting closer now to the limit of what's provided by the spectrum of the sun and by the electron energy structures inside these materials. The real imbalance in all this was the relative competitiveness against gas and coal. When we compare these energy sources, what we're trying to do is we're trying to say, what's the total lifecycle ownership? What's the cost to build your power plant? What's the cost of ongoing fuel to serve it? What's the ongoing cost of maintenance? And we try to harmonize this on a like-for-like basis. And it's never quite like for like. It's at best apples to pears, at best, but we try to harmonize this.

Michael Vogel:

And again, not to belabour the point, but this used to be a close call in very sunny regions where you worry about getting sunburn. Compared to other prices, natural gas and coal prices have gone up so much that even if you say the cost of the power plant is free from now on, just operating this thing on a variable basis, in many regions of the world, solar and wind today have a lower new starting cost.

And again, there's a lot of caveats around this. Building a power plant is slow, they last for 50 years, commodity prices can change. There can be all sorts of long-term contracts around them. So it's not that suddenly every existing power generator's going to go bankrupt. There can be decade-long contracts on both sides of these things. But as people start thinking about the next power plant that's going to be built, it's suddenly become very compelling to switch to solar or wind.

Rob Campbell (10:36):

Just to make sure that I got this right: as I understand it, there are basically three costs that you have to think about with these things. One is just the upfront cost to build the plant. There's the cost to run it. Well, and I guess the third one is the same as the first one, but ultimately a cost to replace it at some point in the future.

Michael Vogel (10:51):

That's right. So, something like a natural gas plant upfront when normalized for power output is going to be a lot lower. This looks like a small factory compared to covering acres and acres and acres of land with these other structures.

Justin Anderson (11:04):

I was going to come to your rescue there, Rob, and say, "there is a third cost!" [laughs]. It's a very important third cost, which is the cost to the grid that you're participating in. When you're introducing different types of power, you're introducing a very different type of cost. What I wanted to do is just tackle—because there's a couple really interesting points there—the apples to pears comment really got me perked up here. I actually think this is really, really, really critical.

It's not just… I would say it's not apples to pears, it's like apples to Lamborghinis. I mean, we're in a completely different state. The example I like to use is, if you were talking about… instead of power, delivering power to people, let's say we were talking about delivering oxygen to people. And would it be reasonable to compare the cost of delivering oxygen to a scuba diver versus somebody who is breathing normal, ambient air?

And the answer, I mean, it's obviously this is an example just to get the mental model going, but the problem with these comparisons of when we're comparing types of power is we're making that same problem. We're comparing things that are fundamentally not comparable. The nature of power is that when you need it, when you demand it, you want it the moment on demand. And when you don't want it, when you have too much of it—just like maybe oxygen in the ambient air—you're not willing to pay anything for it. Having something available when it's needed is absolutely critical.

Justin Anderson:

And one of the kind of inspirations for this conversation I wanted to have is exactly what you were laying out there. We talked about capital costs, we talked about operating costs, but that third cost of what happens when you introduce power that's unreliable to the grid, how does that affect the overall cost of the system of delivering electricity to the end consumer? And for doing that, you cannot look at each individual source of power, line them up on a spreadsheet and say, okay, this one is $10 per LCOE (levelized cost of delivering the electricity), versus coal is X and oil is Y. The best measure to look at how you're affecting the cost is to look at the price that people are paying for electricity in the grid.

And there're multiple examples of that we can look at around the world of countries that have really pursued this. And we can get more into that, the details of the countries, but I mean, maybe this is where we can have some of the cost discussion.

Rob Campbell (13:10):

Well, I feel like some of the biases are maybe coming out here—these "unreliable sources of power." Basically this is like, if it's cloudy, your solar cells aren't going to be operating and delivering the power to those that need it. I mean, is that the basic idea?

Michael Vogel (13:21):

It's even simpler to Rob: just at night, it doesn't work either.

Rob Campbell (13:24):

Oh, there you go.

Justin Anderson (13:27):

I don't think we're quite yet at biases. I think happily we're still in the realm of physics, but I'm certain that we will be soon in the realm of biases [laughs].

Rob Campbell (13:34):

Got it. Well, on some of those things, maybe… you mentioned different parts of the world. How do either location or other factors impact some of these choices? What are some of the constraints on the ability to move in between different sources of power?

Michael Vogel (13:49):

It's much simpler than you think. Places you're worried about getting sunburned, the solar resources are great. And if you're not worried about getting sunburn, they're not good. And the wind is as obvious. The other way to think about it is, you're not going to build a big hydropower facility in the middle of the Sahara Desert, and you're not going to build a big solar facility in Northern Quebec. All these physical resources are self-evident. Moving power across regions… it depends by continent. Some places have wider grids, some have smaller ones, some have cross-border trade, some don't. That's really digging into the details of it. And certainly the wider geographic diversity you have, the easier it is to handle different power sources coming on and off.

Rob Campbell (14:31):

Justin looks like you're itching to get in with something here.

Justin Anderson (14:34):

You made a really good comment, which I think is common for how people think about it. It's like, okay, well, the solar might not be on all the time and so that affects the cost. But the point I'm trying to get across here isn't that you shouldn't do renewables, I guess what I'm trying to say is that there's a cost involved. And it's not the cost that's being distributed by investment bankers and by others who are very keen on people who are interested to see money get spent on these transitions. They're producing a line item, a set of costs, in order to sort of send the message that, "Hey, renewables are this really cheap form of energy now and natural gas is expensive at this point, so we can make this transition." And I think what happens when we look at it like that, is because we're doing the apples-to-pears analysis, we're losing the point that incrementally, you're still going to be increasing cost as you move to a higher percentage of renewables.

And the proof of that is if you look at the European experience—[it's] kind of the best experiment out there—where you have multiple countries [and] it's almost a perfect correlation on how far they've pushed the wind and solar specifically. So for example, Denmark is something like 50% of their power is derived from wind and solar. Germany is at something like 30%, Ireland, 30%. Spain, 30%. And those countries all cluster at sort of 30 to 35 cent (euros) is what they're paying for their electricity. And as you get to countries in the same continent that are very low on renewable penetration, 10%, 5%, Hungary, Bulgaria, Poland, those kinds of countries, you're getting down to 10 cents. You're one third—or even less—of the price of power. And obviously every single country has its own unique circumstances, but the correlation is sort of overwhelming. You can't deny it.

And so to kind of put forward the thesis that "Hey, wind and solar is now cheaper than coal and nuclear," I think it's a real disservice to the investment community of just making that statement because you're not actually telling the truth. And I think it's critical that it might be cheaper to build turbines than it was in the past, for sure. And if you look at the turbines in isolation from a coal power plant, absolutely, it might look like it's cheaper. But when you look at it from a grid perspective because you're introducing that unreliable power into the grid, you still have to have the same amount of peaking capacity, of base capacity for when the wind and the solar isn't available. So that means that you're essentially deploying more capital than you would've had to deploy in the absence of going down the path of renewable. And that means you're increasing the total rate base and the cost.

Justin Anderson:

So, there's both a kind of inductive evidence that we see in Europe and then there's sort of the deductive logic if we can get our head around it.

I just feel like this conversation isn't really out there. That's the message that I was hoping to make sure that we have this conversation, discussion and make sure I'm not missing something obvious. Like maybe there's some aspect to this debate as an investor, I'm looking at it and I'm like, ah, you're missing X. Point to what you're missing.

Michael Vogel (17:24):

The Germany case is peculiar. Germany was a very early adopter, which means what they paid to install solar is probably at least 5x the price that they would pay today if they were to do it brand new. And the people who built it—they charged those prices and the electricity prices were fixed to that. There's this time-lag effect where there's this capital recovery cost that would be much far lower today. Literally probably a factor of five or so.

Justin Anderson (17:51):

Yeah, no, that's absolutely fair. And it may be that if you ran the experiment starting from today, it would be different. I think that's a great point, but still it doesn't get at the critical point, which is you're overbuilding your capacity that you would need to have otherwise. Let's say that the technology even cuts in another half in terms of the cost. You still are deploying cost that otherwise you would not need to deploy, meaning capital cost. In the power world, most of the cost is the capital cost. The operating cost tends to be much lower.

I mean, it depends a little bit on which source you're using, but that capital cost, that outlay literally wouldn't exist. And you could have the same amount of total capacity for the grid if you didn't spend it. So, the critical element of cost isn't the absolute cost of the turbine. It's the fact that you're building the turbine that you would not have had to build. Or the other way to say it is, if you build the turbine, you still have to build the gas plant to back it up—regardless of whether you build the turbine.

So it's sort of this unnecessary capacity that gets shoved into the rate base and so that's what pushes it up. But I agree that the extremity of the cost growth, if you did it today, would probably be less so because of technology improvement.

Rob Campbell (18:57):

In that example you're doubling your capacity, you're not using the gas plant that you build as much as you would otherwise—you're really just using it in those, for peaking, I suppose, or when it's needed. And it's the one that flexes so the cost saving to the overall grid isn't there. I think I've got a better sense of that.

But I mean, these are choices that were made by governments and people… I guess this is where the ESG aspect comes in a little bit. Can you guys just talk a little bit more about that and how that plays in?

Justin Anderson (19:22):

I want to jump in on this because I want to be absolutely crystal clear that I'm not saying that I'm against renewable power. That's what it probably sounds like. What I'm saying is I'm against people manipulating cost data. If we're going to go down this path and say, look, we want to produce energy we're willing to spend more to do it because we want to offset some carbons. That's absolutely fine. That's a value judgment that I think is up to every individual to decide what tradeoffs are involved. That's certainly not what I'm trying to argue here. Where I'm trying to go with this is to have the conversation that isn't being had, which is, what is the true cost of this stuff? It isn't the levelized cost of this versus that. It's what is the actual cost? So anyway, so without harping anymore on the cost [laughs], should governments go down this [road]?

I mean, I think the answer is whether or not they should, they are. This is the direction that the world is going. I just heard from our own Calgary City Council, they announced a—I can't remember the number—but billions of dollars that they're going to spend on exactly these sorts of renewable initiatives. And Calgary certainly isn't sort of a first mover in this regard. I mean, there're places all around the world that are doing this. I think the fact of the matter is people have decided they're voting with their feet, that they are going to take on the cost, they are going to build out these new sources of power. So we as investors sort of have to react to that.

Rob Campbell (20:39):

Mike, are you in the same camp as Justin? Are you as concerned about this as he is?

Michael Vogel (20:44):

Let me just go back. Justin's absolutely right that—I'll take the extreme version—you can't suddenly switch overnight to all solar and wind. Again, the existing plants have very long lifetimes and he's absolutely right, there's a certain amount of redundancy that's needed. There'll be some sort of battery storage that starts creeping up in different places but it's frankly not enough. You really do need these backup sources. More what I would emphasize is these backup sources—their costs went up a lot with the price of natural gas. It's not like their costs stayed consistent, their total use cost somehow stayed flat, and the whole renewable thing is just redundant. I'd say whatever economics or balance there was, if natural gas prices stay where they are, that equation is going to tilt a lot more towards renewables.

One other point I would want to bring up on the ESG thing: I think there's some bad news and some good news. The bad news is there's an inherent tension we're always going to face between the E and the S. On the S, globally people consume. And across the world, there's more and more people who want to consume. We're not going to give up our refrigerators. We're not going to give up our ovens. It would just be unimaginable for us to somehow insist that people who have never had a fridge or oven, don't aspire to one. So there's going to be more energy consumption. And that's always going to be at odds with the best environmental outcome, which is just… people consume less. There's no easy answers to that. And I just want to get that out there. There's always going to be this very difficult tension between the two. The good news is—Justin and I might disagree a little bit, but the fact is we're arguing about pennies. And it's really good news that we just have all these alternatives to even think about.

Michael Vogel:

We're not in some sort of pinch situation where cost of living is really distorted by the price of the coal. It obviously isn't. We're not in some very vulnerable situation like Japan was after Fukushima, where people are reaching for a plan B. It's very good news that we can even discuss these alternatives and that we're even—maybe we're arguing about nickels—but we're on the range of pennies or nickels. I'd say the good news is just having the diversity and having all these different options is inevitably good for people. Yeah. Anyway, that's where I am on the ESG side.

Rob Campbell (22:50):

Well, speaking of options, we're investors, we make decisions, we choose from among options. Can we take the discussion to some implications as investors? So we've got the context, we've got some changes happening, both with [respect] to technology as well as price. Like you mentioned, different environmental and social influences. As investors, where does this all come back to? And where are you guys seeing either risks or opportunities.

In a way, I can envision a world in which a lot of capital is needed to create these options, people have to offer return on that capital. How do you think about that from an investment perspective?

Justin Anderson (23:23):

Well, I'll just take one stab and then pass it to Mike. One thought I have is, I do see a tension here. I see a tension between the economic place that you would go if you wanted to achieve low emissions at a low cost. I think you would go down a very different path of, say, nuclear with your peaking capacity, with natural gas. And you could get there actually at a lower cost than what people are paying today or a similar cost. Or this path towards renewables. I actually do disagree a little bit: I think going down this path of renewables is going to be very expensive. I think we've seen that already across the board where it's been tried. I suspect that that will continue. And that doesn't mean we won't do it.

So, I think as investors, we're in this place where you have to kind of play both scenarios. I think the one scenario that's sort of been pounded into a lot of folks is that we are going down the renewables pathway. And there certainly is another option to get to the same low carbon, but maybe at a lower cost. And that option may play out. So I think as investors, [the] message I would say to people is just keep an open mind on these. It's not ordained that we're going down this pathway 100%. Certainly looks that way now, and that's the direction that things are blowing. But five, 10 years from now, you could definitely see a shift. I think it's just about keeping an open mind in terms of these long-term themes.

Michael Vogel (24:42):

What Justin mentioned about keeping an open mind—I think there was a number of different industries that were based on an idea of certain regions or certain localities having an exceptionally low cost of electricity or cost of energy. And that just might not be static. There can be funny situations where historically one chemical industry was based for the idea that they had cheap natural gas, that they were somehow converting into electricity on site. That might move around the world, that might change a little bit. So I think those kind of dynamics are something to keep in mind. Certainly the electrical grid is just getting busier. I think there're options there. There're other parts of this whole energy story.

Michael Vogel:

If—I'll take the scenario where Justin's right and let's say energy costs do creep up—well, if you think about the total consumption basket, people will tilt away a little. So, there might be more ideas and energy-saving technologies, whether it's on better building insulation, better water heaters, those kind of things. So, we do try to look across the whole industrial world—well, I guess, also the consumer world as well. We try to think about all different scenarios, how this could evolve.

Rob Campbell (25:45):

What kind of exposure do we have to these themes today across our portfolios?

Michael Vogel (25:49):

So, we have exposure to building insulation. We have some exposure on the utilities where investors are effectively rewarded for how complicated the grid becomes and how much money becomes invested in it. We don't have much in natural gas. And like I said, the price of natural gas didn't shoot up because the world resources were instantly depleted. It came around for a number of upsetting reasons around the world and kind of a collective reluctance to reinvest in the industry. But that could change and natural gas prices could come down.

Justin Anderson (26:21):

Energy touches kind of everything. You could really have a long list depending on how wide or broad you want to make your definition. Enbridge comes to mind in the [Mawer] Canadian Equity Fund as a major mover of energy. Often energy is one of these industries where it has the most indirect impact. If you have a high cost of energy, that's going to cause you to be less competitive if you're producing goods that require a lot of energy. Because often energy is kind of an input cost to certain industries. So that's… in general, it can affect country-level competitiveness questions.

Rob Campbell (26:53):

It strikes me, though, that it doesn't seem like we've invested [in] the examples that you mentioned. With respect to water heaters and insulation, I think we do have some investments that are really leaders from that perspective and that technology—[but] it strikes me that we haven't yet invested (or at least historically) in companies sort of at the forefront of technology and renewable power specifically.

Is there a reason for that? Are we waiting for some of these cost projections to really change?

Michael Vogel (27:17):

There can be very exciting technology, but I don't think we're going to invest in them. I mean, we can read about them and get excited, but at the end of the day, electricity is a commodity. These are usually priced on "lowest price wins" kind of thing. Often very limited returns—returns that are frankly too low for what we should be providing in an equity portfolio. (Might be more suitable for a lower expected return portfolio.) And as exciting as technology is, it's fast changing. And we want to hold our investments for many years and we're just unlikely to get involved in anything where there's just a lot of leapfrogging coming along.

Rob Campbell (27:55):

And if we go back to sort of the core thought that, "Hey, costs on the one side have risen. The comparison of cost projections looks a lot different today than maybe it did a year ago or five years ago. And hey, that's not the full picture—you got to look wider when thinking about these cost projections." What are some things that we haven't really talked about that would completely kind of like… blow up [laughs] everything that we've spoken about today?

Michael Vogel (28:18):

Let's talk about nuclear fusion. And this goes back to—I know Vijay's been on the podcast, who's talked about giving the analysts plenty of room and plenty of resources to explore topics that aren't necessarily investible today—I got the chance to spend some time looking into this. There was a lot of fundraising and a lot of excitement, and I wanted to spend time saying, "is this legit? Or is this just fundraising nonsense?"

I'd say the story is more reasonable than I expected it to be. Nuclear fusion has been accomplished here in laboratories for about 50 years. So the question, "why don't we have this as a power source?" There's actually a pretty good reason. When nuclear fusion is conducted here in this equipment, what happens is they have a big metal pipe and they accelerate these subatomic particles up to about a 1,000 km per second.

What happens is these particles have to hit one another and fuse and release energy before they hit the wall of the pipe, because if they hit the wall of the pipe, they just cool down and nothing happens. So if you think about how these experiments were run, it took a lot of energy into this to get these particles all revved up and moving fast. But so few of them collided with each other, diffused, that at the end of the day, it took more energy in to speed them up than was released when the very few of them that actually collided released energy. But the general mechanics, the general geometry, the general machinery is all there. What's different this time? There's much better magnets out there. In one case there's just better systems available to keep these particles off the walls of the pipe. One we looked at… it uses much stronger magnets than were available. It has to do with the new family of superconducting magnets.

And I had the time to walk through all the equations as best as I could. And it looks like if you go through all the calculations they used in the past with this higher magnetic field, there should be enough particles colliding with one another, rather than just hitting the walls, where there is net power released.

This is still unlikely. It's one of these things that it's just not there until it's there. It's dealing in an operating regime we humans just haven't dealt with yet. These projects are under construction. And we'll know probably by the end of 2023 if this is legit or not. So, if this happens and nuclear fusion really is—it's just this dream outcome. It's all the benefits of nuclear power, reliability, low cost; there's no big block of fissionable material, there's no meltdown or disaster risk. If this works, this podcast will have been truly pointless. It'll just be game over. It'll be there. So—

Justin Anderson (30:42):

Amen.

Michael Vogel (30:43):

—It's not there yet. But I do appreciate the culture here at Mawer, what Vijay's offered us, the ability to go out and explore these kind of topics and think about how they'll affect the portfolios down the road.

Rob Campbell (30:53):

What about for you Justin? Like, One that springs to mind that we maybe touched on just a bit earlier is just like the whole storage thing. Like if that can be figured out, doesn't matter that it's not sunny at night.

Justin Anderson (31:02):

I'll be your number one renewables booster if we have a breakthrough in energy storage. I think there's nothing that is more critical to that technology to take it from out of this political realm (which would be so beautiful) and put it into this economic realm of something that we could really use. If we had a breakthrough in storage.

I mean, there's different ways that you can store energy. The classic one is pumped storage. That's how we do most of our storage today, where you—when you don't need power—you use the excess power to move water uphill. And then when you're ready to consume it and the wind isn't blowing, you just unlock the turbines, let the water come downhill. And that works really well if you have it, if you happen to be close to a place where you can have a reservoir. And historically that's been the economic version of storage (utility scales, energy storage). The other types of storage would be your batteries; flywheels is another typical one where you're leveraging kinetic energy to store; compressed air is where you pump air down into caverns underground. When you need the power, you can pull it back out. And then there's ultracapacitors.

So there're different technologies that people are playing with, but my personal view of it is I definitely think that these technologies as Mike was kind of alluding to—a lot of them are reaching some of their kind of engineering limits. I do take more solace in something like fusion where I think maybe it's more hope than reality, but it would be wonderful because there's nothing that has been more beneficial for humanity, for lifting people out of poverty, and from an ESG perspective than low-cost energy. And it's almost perfectly correlated with people coming out of poverty are those who consume more cheap energy. So let's hope that we, as a species, can figure this question out.

Rob Campbell (32:35):

Interesting. And then—usually Justin knows this, but when he comes on the podcast, I usually give him a different job. Mike, maybe I'll give you the job today. But if you're a power grid operator, say, in Eastern North America or something, what are some things that you would either do or recommend or be really thinking about today that you're not seeing out there in the market?

Michael Vogel (32:52):

I'd strongly be promoting electric cars because [laughs] that's got to be the biggest win for my business if I were a power grid operator. I'd be talking to all the luxury malls and the shopping plazas and telling them it'll bring in the Tesla owners, it'll be good for business, people will stay longer and shop. I'd certainly be promoting them.

Michael Vogel:

The switch away from natural gas heating to electricity is not easy. That's very, very complicated. And that's going to take a very long time. I'd be pushing on that over time. In theory, it's the best outcome because ideally in 50 years we'll have more renewables and my electricity could be powered by renewables instead of just combusting natural gas in your basement. But it's not an easy switch. And that's probably the big one I would be spending time on if I had a multi-decade horizon as a grid operator.

Rob Campbell (33:39):

Interesting. And then maybe the last one for you, Justin, I don't know what job I'm giving you here, but the comment that we're kind of arguing about pennies and nickels... I guess that's true. But I think also, and we've seen this just with inflation generally in different parts of the world, higher levels of inflation tend to be associated with higher levels of political unrest and strife. So, are we really talking about pennies and nickels here? Or is this a bigger conversation? Something that's a lot more meaningful?

Justin Anderson (34:02):

I think—you remember a few years back—I don't know if they're still out there, but it was the "yellow vest protests" in Europe where people were protesting the cost of energy. The difference between 35 cent versus 10 cent kilowatt hour energy is massive for a lot of people. One of the most regressive costs out there is energy because we all pay the same price rich or poor, and it disproportionately hurts poor people. I'm absolutely concerned about it. I think if we want a sustainable way to drive down CO2, we have to take a hard look at what we're doing because costs are a huge part of sustainability.

I think it's a major problem. I mean, I don't want to get too much into the advocacy side here [laughs] or my mindset out there, but I am worried about we aren't having a proper conversation about cost. They are, I think, a lot more significant than is being sold to us. If we are going to go down that path, we got to sort out whether we're willing to incur the cost as a society because there may be a lot of implications.

Rob Campbell (34:55):

Well, the last podcast that I recorded was with Paul, our CIO, and he was talking about decision making—good decision making—and one of my takeaways from that one was just the "3 Cs," or things that lead to better decision making: context, cognitive diversity, and communication. And so, I guess as I think back on this conversation that we've had today, I just want to appreciate you guys coming on and sharing your views. I feel like I've got a lot better context. We've heard some different viewpoints done in a way that—as opposed to, perhaps, many political conversations on these types of topics—[was] just done in a way that leaves me open and curious and looking to learn more. So, just want to thank you guys so much for coming on and any final thoughts before we go?

Justin Anderson (35:34):

You mentioned cognitive diversity. I like how this conversation sort of really highlights that in our team. That we do have this openness and willingness to go down that path. And this has real dividends for the team's investments because there's actually science behind the kind of the "wisdom of crowd" effects. And if you can get people to speak their mind and feel safe to do so and say what they believe—because we all see a little bit different part of the world. We've got our own unique set of experiences and our independent pieces of derived information. And that's why the "wisdom of the crowd" kind of science sort of works. I'm grateful that we could have this conversation. And I think this conversation is reflective of the culture that we have in the Research team where cognitive diversity is encouraged. I see it all every day, and it's really one of the things I appreciate most about working at Mawer.

Michael Vogel (36:19):

I'll add two ideas. One on the cognitive diversity one—let's say Justin and I had this conversation for another hour and we both came to the conclusion that, "Hey, there's just so many unknowns. There's so many variables. This is so erratic. This is frankly just too messy to solve." Well, we have the flexibility across the portfolios that we don't necessarily need to commit one way or the other. Justin and I can go look at pharmaceutical companies or we can go work on something we feel like we have a better grasp on what's going on. By no means are we obliged to come up with one dedicated answer on this topic.

The second thing I'll leave you with—it's more of this kind of poetic image I like—just imagine 2,000 years from now, and there had been some sort of technological dark ages that we went through and people come back and they look at us today and they hear these stories or read about these tales of, "someone used the sun to cool down a house? What kind of weird myth is that? What kind of weird paradoxical fantasy legend is that?"

If anyone's listening 2,000 years from now and unearthed this, I just want to let them know that we really did that.

Justin Anderson (37:23):

[Laughter] On that note...

Rob Campbell (37:30):

[Laughing] Ah, great. Well on that note—and actually that was one of the real uplifting things that I took from the conversation, Michael, was just your point about the options as a society. We can argue about the cost side of things and all that, but probably a net benefit that we do have these options available to us.

Gents, thanks so much. And looking forward to having you guys back at some time in the future.

Justin Anderson (37:48):

Thanks Rob.

Michael Vogel (37:48):

Thank you Rob.