

Meeting Summary: Solar Panel Recycling Commission

April 26, 2021 1:30 pm – 3:30 pm

Attendees

DEP: Dan Clark (DC), Karen Kloo (KK), Scott Brubaker (SB), Nick Baier (NB), Nick Nader (NN), Ashia McRae (AM)

Non-DEP: Jim Entwistle (JE) -via phone, Dunbar Birnie (DB), Joseph Ferrante (JF), Dr. Stephanie Lee (SL), David Thompson (DT), Chris Gulics (CG),

DCA: Sean Thompson (ST)

The following is a detailed summary of the discussion and is not a word-for-word transcript. The purpose of the summary is to capture ideas expressed by the Commission members.

Topic: Managing Solar Panels as Universal Waste

NN: In December 2019, Commerce & Industry Association of NJ approached the department with a request to include EOL solar panels in UW program. The department reached out to EPA; and EPA responded indicating that they have no plans to add solar panels nationally and advised if interested on a state level to proceed with inclusion of EOL solar panels as UW. Individual states have latitude to adopt how waste streams are managed if they meet certain criteria. If NJ went that route, the next step would be to submit a rulemaking petition, including draft rules with comment period. This may be good idea but may be premature because it would preempt the purpose of this Commission. However, it is a possibility after conclusion of this work.

NN: Contacted CA Department of Toxic Substances, Control which administers hazardous waste (HW) and UW programs in CA, to request information concerning management of EOL solar panels as UW. No response has been received as of today (April 26).

KK: This possible approach will depend on Lyle's findings. Lyle previously stated that he believed that a small percentage of solar panels contain hazardous constituents, but it is not a closed subject. The earliest panels contained lead solder, but the use of lead has been phased out. Lyle further stated that the cadmium telluride solar panels are small percentage of the market. Lyle's assignment from the last meeting was to determine the percentage of solar panels that would be hazardous, possible labeling and tracking of these panels, and any advanced recovery fee program that may have been instituted for the cadmium telluride panels.

DB: Categories of UW means something has to be toxic enough to deal with in this manner? Do we need to decide whether the encapsulation or the amounts of cadmium/lead whatever else are small enough that they wouldn't have to be dealt with as UW?

KK: First, we need to determine the percentage of panels that contain lead and cadmium.

DC: Also need to determine if there is lead, is it only in the frame or other parts of the panel, and whether it can be separated.

CG: We went through a lot of this at PSE&G sometime before I started. We find that the solder is integral into the membranes because it's all the electrical connections, happens more in the older panels than newer. Early on in the industry, a lot of the panels had cadmium and lead and they are the

ones that will come out of service sooner. Newer panels have reported lesser toxicity. It is a very prescribed method for proper destruction and testing to determine if something like this is HW vs non HW. We did quasi-testing, I wouldn't rely on it, but we did on older panels, and came up with hazardous levels of lead & cadmium in these panels. Not to say it met any criteria, but we just did it as an experiment in a sense. My question on the UW side is: I think it is likely we're going to lean that way at least for a majority of older panels that we may end up having to rely on manufacturer knowledge of what would be hazardous or non-hazardous. Since the manufacturers would have had to dispose materials throughout their manufacturing process, they should have made some type of determination. We relied on generators' knowledge in the past too, but, PSE&G has nine or ten different types of panels.

DT: It looks like thin film cadmium telluride panels were not really installed in NJ, there were very few early projects. They are currently 5-10% of the marketplace and are primarily used in utility grade installations. We should not see any of this type of panel in a residential marketplace. I also have been interested in the toxicity issue, speaking in general terms in Panasonic's case, we began to experiment with lead free solder in 1995 and in anticipation of lead becoming an issue with the solder, which were conceptualized in 2003, 2004 timeframe and took effect in 2006. I can't say that every particular product was made with lead free solder, but there was a major change in the electronics manufacturing processes to switch to lead-free solder in 2006.

I also came across a study that was done by the International Energy Agency, something called PV Power Systems Program, where they work with EPA Protocol 1311 to try to determine the human health risks associated with solar panel installation in unlined landfills. The study concluded that it would be less than the EPA one in ten to the minus 6 cancer risk. I don't know how helpful this information would be to this group. It did seem like it provided a lot of useful information on how panels would likely behave in an unlined landfill.

KK: Are your panels labeled so one would know if they are lead-free or not?

DT: I don't believe so. All they would say on a label is either Panasonic or Simeo and a model number. I don't believe they are labeled to say lead free solder. It's unlikely.

CG: Should we consider approaching the UW petition in concert with what we're already doing now. It looks like for at least some of the panels out there are thin film, are older and we have a number of arrays out there too. We also have ground and roof-mounted panels installed through our Solar for All programs in addition to all our pole mounted panels. We still have some time before those larger arrays come out of service. Hopefully, we won't get any major storm events that takes them out prematurely. We do have a number that come out every month from the poles. We have approximately 185 panels that are taken off utility poles each month.

DB: I have never seen labels that would list the toxic components in a module. The information contained in labels may be limited to the manufacturer's name and purchase date. It would be difficult to track down components, as modules are sealed and their contents are not publicized. It would be interesting to know the types of testing that are conducted by PSE&G on damaged/broken modules that are taken out of service. If you have say, 1,000 such panels, made by the same manufacture, then you may only need to test one panel to determine how to manage the entire array of 1,000 panels.

AM: Does anyone know if there is some type of national registry at which manufacturers register model number, manufacturer, and hazardous waste constituents?

DB: I'm not aware of any. One project we had been talking about amongst solar manufacturers is we're working with Underwriters Laboratory (UL) to incorporate a module type label in the UL standard. So that would be a requirement by UL to label the module type of chemistry that it is made up of.

Topic: Oversea Solar Panel Products and Recycling

DB: Veolia has a recycling plant in Europe for solar panels. I need to find out more about what they do at these places for thin film silicon. I'll circulate the Nature Energy article to Ashia for distribution. This is about disassembly and components of silicon modules. Addresses features of the metallization and different components, the silicon wafers themselves, aluminum frame, but the layers that are used to stick this all together are so rugged they last for decades and so this is the difficulty in taking it apart. I don't think there's any hope of reusing the silicon wafers. The article has data on recovery rates that are possible for different parts in these kinds of things. I have another article on the topic of solar. This is a relatively recent report from VA Tech to First Solar about cadmium telluride modules. I thought there was a system in place by First Solar to financially protect the recovery of their modules. I haven't found that story yet. But this is a report that covers the toxicity and kinds of things that we were talking about. I'll circulate. This report confirms what we've been saying that cadmium telluride modules are only a small fraction of all modules. We might have to figure out if we can do an easy test to determine hazardous v. non-hazardous.

JF: First Solar did initially try to reserve money as part of their sales process for recycling. But they stopped that. I think they now have a fee for service type of approach. They made that change 2015'ish.

DB: That's very likely. I have not been tracking it. That's one way to do it, if they were going to recover it themselves. You could be right that they no longer do that.

JF: I don't believe so.

ST: One question-is every country using the same products?

DB: I would think so. We're buying them all from China. I don't know of any that would be different standards for a European market when compared to US or China or other places. Sometimes there might be a preference in America for American made, or in Germany for German made. Chinese costs have come down so much that it's almost impossible to meet that, so we mostly benefit by that low cost.

ST: How many Chinese companies actually produce this product?

DB: I think there are many. Lyle had some information last month that was about Grade A manufacturers.

Group: Bloomberg Tier 1 Solar Panel Manufacturers' List

DC: Wasn't it about 20 or some companies in that list?

Group: 25

DT: We're a global manufacturer and our goal is to manufacture one product for a world market. I would think with solar panels, aside from different voltages, that the panel itself is the same. It's just the connection specifications because there are different voltages.

Topic: Downstream Markets

JE: One thing I looked into is the people that are processing the solar panels in the country. I reached out to one of the largest companies that process panels-Cascade Eco Minerals in Springfield, MO-a division of Deluca Glass. Deluca Glass is one of the largest processors of glass and has been in the market for years. I spoke with an Executive with a ton of experience in e-waste glass processing. My goal is to review operations as much as possible but there was not much he would tell me as the information is proprietary. We reviewed the panels, the makeup, to determine the recyclability of the materials and to set up a recycling business partnership to figure out if there's something that we can start here in the state and partner with someone that is doing the process and doing it well. I asked his suggestion for a viable recycling program and what his thoughts were on that. The results were basically Cascade has a proprietary process for handling solar panels. They re-mineralize the glass to create feedstock, to manufacture new products. They break it down and separate it into its components and it can be blended and resold. Some of the examples of some of their markets they're reselling to: paint fillers, fiberglass, bottles, etc. So, panels are recyclable, but it costs money to do so. There's no high value commodities to offset recycling costs. In e-waste commodities help to offset costs. The panels do cost money to recycle, Chris can attest to this. What I wanted to find out about from Cascade, they wouldn't tell about their process. He did reiterate numerous times of their zero-landfill promise. Everything they bring in, everything they recycle, they have a no landfill promise.

I spoke to them about lifespan coming from a business perspective. E-waste is constantly refreshing new computers are always coming out. I asked him about that and also what he/we call return on investment (ROI) and got off to an interesting point about the panels and I'll ask Dave to make a comment on this with the 200-300 watt panels, taking up square footage. New panels are a 585-watt panel which is double in wattage. He did state that refreshing the panels is happening, it's not just the damaged panels. Secondary markets are shrinking due to refresh-newer, better systems driving competition prices down. There is a little refurbishment, not a lot.

His feedback suggestions for a program: an EPR law probably would not work. He says start with a land ban on the panels, which goes along the with UW we talked about. Stop the flow of materials into landfills. I agree, an EPR would be difficult with charging manufacturers for some manufacturers-it's going to be too difficult to implement. Briefly discussed CA and Advanced Recovery Fee managed by the state. That may be the only way to build up a fund. The challenges would be to forecast recycling changes-but this would be a starting point.

KK: The feedback you got was an EPR is not the length of time the panels last, it's more the sheer number of manufacturers that would need to be involved?

JE: Yes

DC: For context, ballpark, any idea how many manufacturers there are? Thinking in my head how that may compare to the number of manufacturers for e-waste for example?

JE: I don't know the answer to that question.

AM: Lyle said the 25 manufacturers are inside the Bloomberg Top Tier, but there are hundreds of panel manufacturers.

JE: I think Dave can attest to this. Manufacturers disappear in the EPR program, then, all of a sudden, a whole group of orphans appear and all the manufacturers have to pick up the slack of the orphan manufacturers. I just feel that it's an undue burden to put on the manufacturers. Manufacturers can help in other ways. Advanced Recovery Fee is probably best way to go.

DB: There is one difference with other kinds of e-waste, the manufacturing of solar modules over time has been very similar. If you look at computers, there are newer generations of these devices which change much more rapidly.

CG to JE: A lot of programs do have no landfill material, but I found that a lot of the plastics end up going to a smelter in Canada and I don't know if they had mentioned where the plastic waste would end up. The other question I had and Karen you may know this better than me; when we're dealing with a state-regulated UW, when we ship out of state, does that mean the out of state facility would need an EPA id to be able to receive it as a HW? Because our jurisdiction as a UW would only remain in the state?

KK: I don't know the answer to that question. Nick Baier or Nick Nader do either of you know?

NB: I'm not sure.

NN: Well it depends on what kind of facility they are and what the state regulations are.

CG: Considering them a UW-they are considered a HW that falls under the UW category-a state regulated side, right? Therefore, if it's not federally regulated as a UW, then my understanding is that it would have to then be accepted as a HW at a facility approved to accept HW.

NN: No, UW facilities need to have an EPA id number. But they are not a TSDF facility.

NB: Right. Because we have Class D facilities in the state that receive electronic waste, which is a NJ UW. They're not TSDs, they're simply Class D permitted facilities.

KK: I think the question is if the solar panels were listed as UW in NJ, but not federally and they were to go to an out of state facility, wouldn't it have to be a HW facility because solar panels are not federally considered UW?

NB: That is a good question. I would hazard to say yes, I but could be wrong. I will ask to see if I can get a more concrete answer.

CG: I did talk to some facilities including one called Eco Environmental in Arizona. Most of these facilities don't have the ability to accept HW. We were considering the hazardous secondary materials rule to try and get some ability to ship it in that fashion. But there's a lot of other things that come in to play that are beyond the scope of this call. A lot of the facilities aren't able to accept HW that currently do this type of recycling - just another wrinkle. I don't know if it's the few that I talked to who are in that scenario.

DT: We've been active in the Solar Energy Industry Association (SEIA) in establishing a network of recyclers. All in all, I think the SEIA National Network consists of about 10 or so drop-off locations and four or five processors. I think the company that Jim was referring to (Cascade) is probably one of the more advanced ones. In that, the company has a history of processing windshield glass, which is

essentially two pieces of glass with a piece of plastic in between it. Not that different from solar panels. They do have a fairly unique technology for breaking these things apart and I'd be happy to circulate information from the SEIA program. I don't think there is a real drop-off facility anywhere East of Ohio right now. But we are, as a group of manufacturers, attempting to work with the recycling community by vetting them, feeding them with production waste so that they can gain more experience and directing our distributors and installers to them.

JE: That's one of the things I talked with Cascade about. Becoming a drop-off location for them here in NJ, in the Northeast and they were very open to that as an alternative. I love the fact that David's group is looking into "certifying them", let's just use that word to mean that these facilities are being viable alternatives. I actually think in my discussion with Cascade, they talked about Dynamic. Dynamic is their sole collection spot in Wisconsin, and they take all the panels from Dynamic and do their processing. So having a facility like that is a resource.

DB: That wouldn't surprise me-processing can mean many things in this business. I guess if you remove the aluminum frame you're processing in a way, right? The company Jim referred to, Eco Cascade, Eco Mineral, I think it is C.E.M. They are emerging as a downstream processor for these materials. Again, I think they have a good way to break them apart. The panels contain a lot of glue, adhesives, and from what I've been told, those just do not mix very well with shredders-one of the more traditional e-waste processing devices.

JE: Cascade is very protective of their process, as it is proprietary.

KK: It sounds like there's three facilities doing some type of downstream processing: one in Wisconsin, one in Missouri, and one in Texas?

NN: Oh no, there are more. There's one in Phoenix, AZ; another in Nevada. If I could ask Jim or Dave-What regulations are these facilities subject to under their respective states?

DT: I do not believe that any of them are permitted HW facilities. I don't know off the top of my head. I'd have to do research.

JE: I don't know, but I can find out.

JF: There's a couple that I contacted and had detailed conversations with, and they do not believe they are accepting HW.

DB: Are all of these companies doing this on a fee basis? Every module costs \$x or something like that?

DT: I believe so.

JF: Yes, and the question for the market side of things happening is that the cost of de-manufacturing is exceeding the value of the product that they are able to get out of some of the older type panels. It is negative on the financial side. There's a cost to it. When we looked at costs of what we are paying on the HW side versus the ability to recycle, the cost was not that different. It ended up shaking out pretty close to the same. But there is invaluable cost of the environmental benefits of not having this in a landfill.

NN: The company in Arizona is called We Recycle Solar. The one in Nevada is called Recycle PV Solar. They both claim to do a great deal of solar panel processing. Would it be beneficial for the CEO of one of the companies to be a guest speaker in one of our future meetings?

KK: Yes, it'd be very enlightening.

DB: That sounds great.

JF: I'm happy to reach out to Cascade and ask them.

DT: Karen, I'm aware of one more company in Carrollton, TX. I'll reach out to them and try to determine the level of processing that they're engaged in.

KK: We need to ask the very basic question of what does processing mean-what exactly are they doing?

DT: I think the former ECS International in CA was closed down due to failed leverage buyout. Maybe Jim would know better. I think these two folks in TX are affiliated with them.

JF: The facility I spoke with mostly was Clean Lites in Ohio where they de-manufacture solar panels. I just looked them up, they're still in business and list solar panel recycling on their website among other things.

DT: They're part of the SEIA network. Clean Lites is, Cascade Eco Mineral is, Dynamic is, and Eco International or Eco Environmental is. I think ERI a company in CA is going to join that network really soon. I will send some information on that program.

Topic: Emerging Recycling Technologies

SL: [Sharing a table from a presentation from Illinois Sustainable Technology Center which will be shared later]. Some [of these recyclers] were already mentioned earlier. You can see the amounts here. I was looking into how this recycling actually happens and like Dunbar said, the bottleneck in PV recycling is removing the polymer adhesive layers. There is the encapsulant, which I believe is vinyl acetate and the back sheet which is poly vinyl fluoride. These two hold the panels together and they are very difficult to separate. To my understanding, First Solar, what they do, is try to shred the solar panel first and then separate the glass from the silicon. It seems like, I'm guessing, the removal of these adhesive layers happens through using a solvent. You can use organic solvents, they are hazardous as well, and then you have to treat the waste stream. I think this is where it's being dissolved. I think the research into recycling silicon solar panels is trying to, instead of shredding everything and making a big mixture and then trying to separate is if you can remove these polymer layers first, then you can mechanically separate the pieces from each other a lot more simply. The one I targeted in on is pyrolysis. This is basically bringing the panels to high temperature in the absence of oxygen to avoid combustion and you can degrade the polymer layers.

The EU is funding a pilot plant to recycle 50,000 solar modules per year. I think this was funded in 2018 and they chose to go with the pyrolysis route. They gasify the polymer layer and burn it in an afterburner. In this example of pyrolysis shown, you can see these are panels treated in the absence of oxygen at different temperatures. You really need to go to 500°C for removal of the polymer adhesive. You can see this black residue that remains at lower temperatures. One area looking forward for advancement is: can we make these polymer layers out of something that is easier to remove?

There is U.S. based research into the pyrolytic process. I can share this article. It details some issues, you need a furnace that is large enough, it has to be done in a nitrogen rich environment, the back layer has fluorine, there needs to be a special scrubber to remove the fluorine. I am unaware of any company in the U.S that are doing this now. After pyrolysis then you can normally detach the different components from each other. As I also said, there's another technique. This is a Japanese company and I think they sell this equipment to disassemble solar panels and the way they address the polymer adhesive is to use a hot blade. This blade can melt the layer to separate the glass from other material. This is commercially available technology. And that's all I have.

DB: That's interesting with the heated blade. Slicing it off.

KK: I wonder how much the machine costs?

SL: I can try to find out.

DT: Was there information on how efficient this machine is?

SL: I do not have any information on the rate at which you could process using this equipment, but I can look into it.

DT: That'd be important to know.

SL: And the cost.

KK: Is there any available information on how many of them are operating? Is there any available information regarding government entities or private industry using this equipment?

SL: For this report, I was focusing more on the technology and process. I can look for more information if there is an interest.

KK: Yes, to see the practicality of using this equipment. We would need to know the cost information to determine if this is an affordable or expensive investment.

Topic: Solar Panel Equipment Leases

JF: I could not find any of the wild west leases used by actual companies engaged in installing these panels. But I did obtain a number of templates which I'll share with the group. These are products of the SEIA and their template can be used by contractors. Again, I don't know how many of them are actually used. The leases are useful as a starting point to see the relationships between contractors and users in the context of residential application. I've read on BPU's website that there are well over 100K residences in NJ that already have solar panels, which is a significant number. I didn't do an analysis of purchase agreements versus equipment leases which are the dominant featured relationship. I wanted to give thought to the leases in the context of the recycling and disposal of solar panels. Looking at the leases that would trigger disposal prior to termination. Termination is usually a 20-year event. These leases are sold using the template as a guide. They're sold for a 20-year term either as a Power Purchase Agreement (PPA) relationship or equipment lease. Some of the equipment leases suggest that it could be shorter, a 10-year term, and in that case, the price would be a lot higher. As we discussed in our last meeting, many of these leases will not be expired until 20 years after it has been put into effect. The kinds of events that typically would create a disposal event would be the usuals you'd expect in a lease,

a force majeure event, uninsurable loss, bankruptcy by one of the parties. It depends on if the supplier can retrieve the equipment and reuse it.

The more interesting aspect would be something that was touched upon earlier and that would be upgrading. Upgrading the components as new technology becomes available and I'm not sure if that leads to some type of public policy discussion regarding lease or PPAs should incorporate some provision for upgrade. If a technology is rapidly evolving, particularly in terms of efficiency, the efficiencies are going from 18-20% conversion to 40% maybe as high as 50%; and if the manufacturers are getting that kind of improvement in the technology, then upgrading the existing installations might be an interesting way to improve the capacity that is available within the state. That is not really an issue that is addressed in any of the leases I reviewed. One or two of them did suggest that upgrade would be available if the customer/end user is in good standing with the contract and are willing to pay a little more to get the upgrade. A cost benefit evaluation by the user will have to be taken into consideration. That is an area that might benefit the state if we look at the impact that might have and if we want to express that in some public policy way. The leases, I haven't seen any real, actual leases. I'm operating from templates that the SEIA group provided. I'll share them with the group. Then, everyone who wants to look at them can look at them and get an idea of the relationship between contractor and user. The question that remains is how effective these leases have been in terms of addressing the issue of disposal. All of the leases will terminate at a certain point and most of them contain provisions that the provider will remove the equipment at its expense. Again, that is a negotiable issue, I don't know how it is provided for in the real world. In the templates, it is the burden of the provider to remove and find a secondary use or dispose of it. I must say it's a work in progress. These are leases that look standard but again, I don't know how widespread they are actually used by those in the field.

AM: I was browsing on NJ Clean Energy website and came across a dedicated page that explains the different provisions allowed under a PPA or lease. According to NJ Clean Energy, there are three categories: Solar Leases, Solar Loans, and PPAs. There are variances for each category type. If you have a PPA versus a Solar Lease or Solar Loan and if there's damage to the panel, under the PPA, the homeowner would be the responsible party, but under the Solar Lease or Solar Loan, the third party is responsible. The type of agreement also dictates who can legally collect/receive tax credits and incentives for using the panels. These provisions vary dependent on the type of agreement.

JF: I didn't see it. Are there any actual leases or based on some type of model?

AM: No, there were no leases, there were templates from SEIA, and the Solar Access to Public Capital Working Group. The page was mostly dedicated to explaining the different provisions contained in the three types of solar panel contracts.

JF: Those options are explained on the SEIA website too. That is good that someone investing in it should know negotiating points that are available to them. Again, what is actually out there I haven't the foggiest idea.

DB: It is really interesting that a customer might decide they want to put in newer panels because of degradation or newer ones might be better and then that would trigger some kind of disposal. Obviously, the older ones would then be waste so thinking about how does that come to pass. But I wanted to spend a minute talking about amazingly high efficiencies coming in the near future. So many of those kinds of popular press news are covering multi-junction solar, which might be built out of

aluminum arsenide (?) family of materials and usually those require optical concentrators, mirrors, or lenses; and so they're not a drop-in replacement for an array that you might have on your house already. If you were to be replacing with silicon there will be some improvement in efficiency but it's not going to be those record amounts. The reports I've seen are overselling the efficiency and not understanding the complexities of the systems that are involved.

DT: From what I've seen for crystal and silicon panels, lab testing conversion efficiencies may be 26%, installations typically run 21-22%, and of course, the cadmium telluride models are a little bit lower than that. Where you see the higher efficiencies as DB was saying, there's either some special light concentrator or maybe some other design. It's very common to see those. NASA, for instance, 44-45% efficient solar panels and those are expensive. I don't know how quickly that comes. There's a newer technology called perscolite (?) solar panel technology that people are talking about, which is supposedly cheaper to maintain. I'm not sure how quickly that's going to get off the drawing board. As Joe was saying, we are making larger panels and there will be some upgrading, but we'd have to look into how significant that is. Lyle said it was happening in NJ, and I do understand it is happening in some regions.

JF: Let me just throw this out maybe as a controversial perspective in the air pollution field, the concept of best available control technology is pretty well-accepted across the board. As it's a technology forcing concept. Does that have any applicability here?

KK: I don't think from a regulatory standpoint it would. Because I would think the markets dictate that. For example, if there is a better panel available, but it is more expensive, it is like buying a car, right?... better car for more money. But that would be the consumer's decision on how much money they can spend.

DB: But it might have a sense for the recycling part seeing this picture Stephanie found of slicing the module into the components. If that does it better, cheaper, then it is something that you would go with and there's a cost aspect to it too.

DT: I think what Joe was talking about was air permit and best available technology, there's a direct link there to exposure and human health that you probably don't find so much in the recycling industry. At least in terms of reclamation efficiency you might find it in terms of environmental controls within the facility.

JF: That is true. But I'm more interested in the notion of technology forcing. The market obviously is a very important- a dominant feature in advancing technology. Yet there is a nudging that can take place in the form of public policy directives. What form they take is another question. You know they can run the gamut from just pronouncements to formal regulatory things that have a product of implementation.

DT: I think we're seeing that in the car market where some states are banning the sale of gasoline powered vehicles. 2030-2035-2040...whatever that may be, they're certainly trying to force change.

JF: We touched upon it earlier when you said landfill banning would be one approach. This certainly impacts on the cost of producing things if the disposal becomes impossible-you're pushing the pricing structure back up the line. From this standpoint of healthy debate, it would be worthwhile looking at this notion of upgrading to force technology. Because increased capacity seems to be growing, but is a

very linear thing. This could accelerate it beyond that even if you have to do lenses or things of that nature and make it attractive; and use the marketing skills of industry to get it promoted. It's something that would affect the disposal if the new installs - have these new features to them that would perhaps, expand their life and make it more attractive.

DB: It's interesting, I saw an announcement from Department of Energy, a new program from the Solar Energy Technologies Office, about modules that would have a lifetime of 50 years. So, they're always pushing the envelope. That's almost a lifetime.

DC: On one hand, I think there's an argument to be made in a lot of fields that if you're planning for circularity and extended use, getting rid of plan obsolescence is usually a good thing. But if you get locked into something for you know, 20 years like we are currently, or 50 years and then something better comes along, how do you weigh that? If we were having this discussion and the life span of these panels is already 50 years, we wouldn't really have to worry too much for another two or three decades. But then in that period, efficiency gains might provide more impetus to dump these panels early.

KK: From a standpoint of next steps, I feel it would be appropriate for the commission to decide what chapters should in the report to give us an outline and framework to stay within. I don't know if the commission members feel like we're at that point or whether we still have more research to do before we break down into smaller topics that could translate to sections or chapters of the report. My goal is to have each commission member take one of those chapters and outline and draft a section or chapter. That can be done individually or in focus groups or sub-committees. I did not give you much opportunity to think about this so I'd like everybody to give me what comes to mind at the moment and in the next week or so email Ashia with your ideas about what should be included in the report, and if you are interested in drafting any of the sections.

DT: I was very interested on the report on recycling technology that Prof. Lee gave. Is there any possibility of the legislative funding solar panel recycling technology or is that something that is kind of off the table?

KK: Our charge from the legislation is for our report to include recommendations for statutory, regulatory, or private sector action. I am not interpreting that as a mandate for the commission to recommend that the government fund a project or technology. My interpretation is that they think this can be accomplished through legislation, regulation or private sector action. But, I also do not know that we are so hemmed into the legislative direction that we couldn't make a recommendation like that. I just don't know if it would get legs.

DT: My two cents would be that we should at least provide a basic overview of technologies so that people can determine that this is something that's going to be more readily solvable or if it is going to take some significant research and development to truly develop some sort of process whereby the value of the materials contained in these products can be captured and that can fund some system.

KK: I think one of the sections should be current practices, who's doing what, where, under what regulatory authority, how successful are they, is this a sustainable practice, limitations/constraints of current practices.

CG: I agree, economics are going to play a significant role. We're going to need to attract business to this. The more local they are to NJ the more cost effective the process could be. Then we have the dilemma of the shipping materials out of state.

KK: AZ and TX have currently operating processing facilities. We need a better understanding of what they're doing and how they're doing it and having them in to talk to us.

CG: I think some of those other states have a lot of real estate, much larger arrays, they have significant storm events and things are damaged. In NJ, we have a lot of homeowner involved arrays, a lot of smaller arrays within NJ because of our size and development. I think it'll increase as we start to look at picking up existing warehouse structure space. I think solar will become more attractive over time. But I think it will take some time to get somebody to spark interest in NJ for de-manufacturing. Also, it's not cheap to work in NJ, no criticism to DEP, but there's a lot of permitting in place, a lot of land use rules, the state's real expensive. We have to look at who is currently doing the electronic waste de-manufacturing because those are probably the likely companies that will then expand their operations to include like this.

KK: Our next meeting is tentatively scheduled for May 24th? Joe, can reach out to see if guest speaker from Cascade can join us on May 24th?

DT: Karen, can we consider one other solar panel recycler? I'm thinking the one in Carrollton, TX?

KK: Yes. Having more than one would be advantageous. If you could reach out to that individual?

DT: I will.

KK: What is the name of the company in TX, Dave?

DT: I think it is Echo Environmental. But let me double check. I think they're the former ECS, an e-waste processing facility.

KK: Another committee member reached out to me and suggested another guest.

KK: Stephanie will do additional follow up, we'll hear from Lyle, and we'll have the guest speakers. I would like you all to come prepared with your ideas for an outline or chapters or sections for the final report. Just so we can start putting pen to paper and identifying our thoughts and areas that need further research and investigation. It's enlightening to hear from people who are so experienced and knowledgeable. If the guest speakers can be confirmed with Ashia, we can take it from there. Thanks everyone, for your time, dedication, time spent outside this meeting doing what is necessary to keep this moving forward. See you all next month.