NoBurnBroome
Science Committee
Endicott NY

July 19, 2020

Honorable Andrew M. Cuomo
Governor of New York State
The Capitol
Albany, NY 12224

Re: SungEel (SMCC) Lithium-ion Battery Recycling Facility Proposed for Endicott, NY

Dear Governor Cuomo,

There is a serious environmental and public health threat facing the Southern Tier on which we need your intervention.

Summary

The SungEel (aka SMCC) facility proposed for Endicott, NY has a sister facility in Gunsan, South Korea, which is the only facility of its kind in the world. However, unlike its sister plant, which is operating in a very large industrial area (8000 acres) where the nearest residential community is located 3 miles away, the proposed Endicott plant will operate with people living, literally, across the street and children playing on adjoining athletic fields. The air pollution control devices used by SungEel were never designed to filter out PFAS combustion byproducts and nanoparticles that can be generated from a high temperature pyrolytic process.

Despite claims by SMMC director Danish Mir that the South Korean plant has operated cleanly for 10 years, the company has offered very little solid and verifiable scientific evidence to support that claim. Meanwhile, research of the scientific literature by the science team of No Burn Broome has discovered that potential hazardous air pollutant emissions are far worse than understood by the DEC when they issued the Title V air permit in March 2020.

We are calling upon you, Governor Cuomo, to treat this situation with the same sense of urgency and thoroughness that the DOH treated the fracking issue and the DEC treated the PFAS water contamination issue.

Specifically, we ask you to require the Department of Environmental Conservation (DEC) to rescind the air discharge permit granted for the proposed facility pending a comprehensive environmental and public health impact review (EIS) conducted in strict compliance with all applicable regulatory requirements.

Such a review should take into account the special vulnerabilities of the Endicott community because of previous industrial pollution from IBM and others and should examine alternative ways of recycling the valuable metals in lithium-ion batteries which do not involve dangerous high temperature and burning processes.

Our research

We write respectfully to provide for your review further important scientific information regarding the following:

a) per- and polyfluoroalkyl substances (PFAS);
b) other fluorinated by-products (including products of incomplete combustion of the hard to burn PFAS); and
c) toxic nanoparticles

that could be emitted from the lithium-ion battery processing facility proposed for Endicott, NY.

Request for Regulatory Action Due to PFAS Concerns

Given the grave public health and environmental hazards posed by highly toxic and persistent PFAS compounds, other fluorinated by-products and nanoparticles, we request that you immediately require your Department of Environmental Conservation (DEC) to rescind the air discharge permit granted for the proposed facility pending a comprehensive environmental and public health impact review (EIS) conducted in strict compliance with all applicable regulatory requirements.

Your leadership on PFAS

As you know, New York State has recently discovered hundreds of PFAS contaminated sites that are impacting or threatening the drinking water supplied to millions of New Yorkers. This emerging contaminant concern first came to light in Hoosick Falls, NY, but has now been revealed all over New York State.

We applaud your leadership in initiating a rulemaking procedure that proposes to adopt some of the strictest Maximum Contaminant Levels (MCLs) in the nation to limit PFOA (Perfluorooctanoic acid) and PFOS (Perfluorooctanesulfonic acid) to ten part per trillion in drinking water – even though it took 5 years for the DOH to make this determination and it is yet to be fully implemented.

We request that you take equally rigorous regulatory action to safeguard Endicott, NY from PFAS pollution hazards associated with the proposed Lithium-ion processing facility.

PFAS and Other Concerns Regarding Proposed Lithium-Ion Battery Processing Facility

These concerns are in addition to our concerns about the four carcinogens that DEC admits will be released (i.e. beryllium, chromium VI, formaldehyde and dioxins) into a community that already has a legacy of increased cancer rates caused by past pollution by IBM and other industries. These are in addition to the risks posed by storing and transporting lithium-ion batteries so close to populated areas considering they are a well-known fire hazard. A high temperature treatment train reaching temperatures above 1800 degrees F fired by natural gas adds to the potential for fires and explosions.

The central challenge of recycling lithium-ion batteries

The central challenge to any process that seeks to recover the valuable metals in these batteries, is to separate the metallic compounds from the binder in the cathode. The binder used is a fluorinated polymer (similar to Teflon) called poly vinylidene di fluoride or PVDF (which we discuss in more detail below). There have been at least five different ways this has been accomplished as follows:

1) Dissolving the Aluminum foil and metal compounds using aqueous acids or alkalis (Chen and Zhou 2014; Gao et al. 2018)
2) Dissolving the PVDF binder using organic solvents (Duan et al. 2018; Natarajan and Aravindan 2018; Zeng and Li 2014).

3) Vacuum pyrolysis in which the PVDF binder is evaporated and collected (Xiao et al., 2017, 2020)
4) Thermal treatment i.e. Pyrolysis followed by burning the gases formed (Cheng et al., 2019; Qi et al. 2019 and Wang et al. 2018).
5) Thermal treatment using molten salt technology to decompose the PVDF binder (Wang et al. 2019a,b).

The details and the pros and cons of these different approaches are discussed in a recent review article by Mossali et al (2020).

The SungEel process uses the fourth and most dangerous approach: a high temperature rotary kiln operating at 600 degrees centigrade followed by an afterburner. The afterburner burns the gases produced in the kiln at a temperature of 1000 degrees centigrade or 1832 degrees F. Even though the *purpose* of this operation is to recover valuable and strategically important metals the *process* involved is akin to a two-stage incinerator. This operation has the potential to emit PFAS and a wide range of other toxic and carcinogenic by-products into the community.

Unlike the sister plant in Gunsan, South Korea, which is operating in very large industrial area (approximately 8000 acres) where the nearest residential community is located 3 miles away, in Endicott the plant will operate with people living literally across the street and children playing on adjoining athletic fields. In addition, the batteries will be stored in a flimsy building again within a short radius of a large fraction of the population of Endicott.

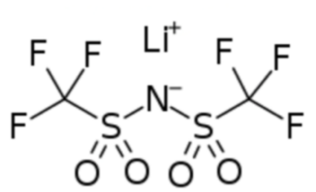
Many of the potential hazardous air pollutants, such as gaseous fluorinated by-products and nanoparticles (which include metals and metallic oxides), would not be removed by the proposed air pollution control devices (a baghouse filter for particulates and a wet scrubber for water soluble gases).

Even though the proposed facility would discharge a wide array of PFAS and other hazardous air pollutants, DEC accepted the limited air emissions data provided by the company without any third-party verification or confirmatory testing and issued a Title V air permit on March 27. SMCC failed to disclose PFAS in lithium ion batteries and the DEC failed to include any PFAS air discharge limitations in the permit.

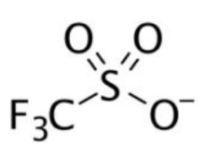
PFAS Concerns Were Not Part of DEC's Original Permit Review

Our PFAS concerns *began* with the discovery that some lithium-ion batteries use lithium salts with a PFAS as an anion, as an electrolyte. These include lithium bis(trifluoromethane sulfonyl)imide and lithium triflate $LiCF_3SO_3$.

Lithium bis(trifluoromethanesulfonyl)imide



Lithium
triflate
Chemical compound



The presence of these PFAS was not reported in the firm's air permit application.

When this matter was brought to the attention of the DEC, the air discharge permit that had been granted was put on hold while SungEel researched the matter, including conducting further testing on their sister plant in South Korea. *To date, the public has yet to be informed of the results (if any) of this testing or how your administration proposes to resolve PFAS public health and environmental concerns.*

However, our concerns go far beyond the PFAS parent compounds themselves.

In a recent EPA presentation (EPA, April 27, 2020) regarding incineration of PFAS as a means of disposal, the author Lara Phelps called into question the ability of incineration units to adequately "destroy" PFAS which *are designed not to burn*. Even if high temperature processing of PFAS can break apart the "parent" PFAS, or fluorinated principal organic hazardous compounds (POHC), it is possible that fluorinated products of incomplete combustion (PICs), either larger or smaller than the POHC (will be formed). Thus C-F fragments could recombine into a wide variety of fluorinated PICs with no standards or analytical methods to measure them. The result could be "destruction" of POHC, but formation of PICs that are unmeasured, unquantified and released to the community.

A simple example would be $LiCF_3SO_3$ (an electrolyte used in some lithium-ion batteries) breaking down to yield a CF_3 radical which could then recombine with another CF_3 radical to form C_2F_6 a short chain poly fluorinated alkyl substance (PFAS).

Empirical evidence that other PFAS and other toxic substances are formed in the pyrolysis and burning of lithium-ion battery components (including PVDF).

In addition to the two PFAS electrolytes identified to date, we write today to provide empirical evidence from the scientific literature for the potential for a range of other PFAS and other toxic products of incomplete combustion (PICs), that may be formed during the heating and burning the materials in these lithium-ion batteries. We believe that all these concerns must be addressed in a comprehensive environmental review that we request you require for the Endicott project and wherever such facilities are proposed in New York State.

Parent compounds of concern in lithium-ion batteries

In our discussion of these potential pollutants, we will begin with the parent product and its function in the batteries.

1) **Lithium hexafluorophosphate ($LiPF_6$)**

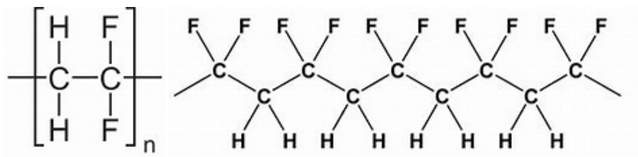
Most lithium-ion batteries use an electrolyte called lithium hexafluorophosphate. When this is heated and burned it produces highly toxic byproducts, which include phosphorous pentafluoride (PF_5), Phosphoryl fluoride (POF_3), and hydrogen fluoride (HF) (Larsson, 2017). All of these substances are highly toxic, but are likely to be captured in the wet scrubber used by SungEel, when it is working properly.

2) **Other electrolytes containing fluorine (or chlorine)**

These include: lithium hexafluoroarsenate monohydrate ($LiAsF_6$), lithium perchlorate ($LiClO_4$), lithium tetrafluoroborate ($LiBF_4$), and lithium triflate ($LiCF_3SO_3$). These other electrolytes will produce many other toxic products when heated and burned, including PFAS in the case of lithium triflate, as explained above.

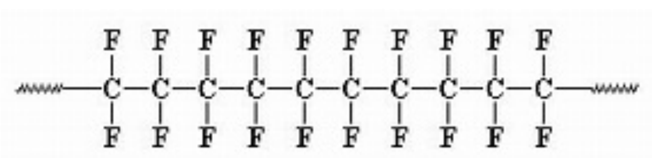
3) **Polyfluorinated vinylidene difluoride** (**PVDF)**

Lithium-ion batteries contain a fluorinated polymer called poly fluorinated vinylidene difluoride (PVDF) which is used as a binder in the cathode. This material has a formula (CH_2CF_2)**n** where "n" is the number of repeated monomer units numbering in the thousands. This compound contains 60% by weight of fluorine. In the SungEel process the rotary kiln and afterburner are used to melt, evaporate and burn this binder in order to recover the metals in the cathode.



Yu (2020) explains in a recently published article: "the Al foil and cathode materials are difficult to separate because they are firmly adhered by polyvinylidene fluoride (PVDF) binder … **Decomposing PVDF using thermal treatment offers advantages of high efficiency and simple operation**… although it is worth noting that the fluorine present in PVDF could be transformed and transmitted into off-gas during thermal treatment of spent LIBs, causing reactor corrosion and air pollution."

PVDF is similar in structure to another fluorinated polymer called Teflon (CF_2CF_2)n which is used in non-stick cookware and is a source of PFAS contamination in both manufacture and disposal.



When these fluorinated polymers (Teflon and PVDF) are heated or burned, they break down to form gases which are highly toxic including HF and potentially hundreds of fluorinated by-products including smaller PFAS molecules and related compounds.

This what the Environmental Working Group (EWG) has said about the thermal degradation of Teflon:

> "Studies show that thermal degradation of Teflon leads to the slow breakdown of the fluorinated polymer and the generation of a litany of toxic fumes including TFE (tetrafluoroethylene), HFP (hexafluoropropene), OFCB (octafluorocyclobutane), PFIB (perfluoroisobutane), carbonyl fluoride, CF_4 (carbon tetrafluoride), TFA (trifluoroacetic acid), trifluoroacetic acid fluoride, perfluorobutane, SiF_4 (silicon tetrafluoride), HF (hydrofluoric acid), and particulate matter. At least four of these gases are extremely toxic - PFIB, which is a chemical warfare agent 10 times more toxic than phosgene ($COCl_2$, a chemical warfare agent used during World Wars I and II), carbonyl fluoride (COF_2 which is the fluorine analog of phosgene), MFA (monofluoroacetic acid) which can kill people at low doses, and HF, a highly corrosive gas." https://www.ewg.org/research/canaries-kitchen/teflon-offgas-studies

Far less testing of the by-products formed when PVDF is heated and burned has been performed, but because of the close similarity in structures for Teflon and PVDF we can anticipate that some of these same products will be generated in the heating and burning of PVDF.

In the case of PVDF, looking at the starting material from a theoretical point of view, it is easy to see how when burnt the CH2 part of the monomer would be converted into formaldehyde (CH2O) one of the air pollutants the DEC has acknowledged would be formed in the SungEel process. It is also highly likely that the other half of the monomer CF2 if released as a free radical would be able to form many PFAS of various carbon atom lengths. A point mentioned by Phelps in her EPA presentation already cited, when she suggests the possibility that "CF2 radicals" will reform "fluorinated alkyl chains" (Phelps, 2020).

Many of these fluorinated by-products, like PFAS, are toxic and highly persistent in the environment because of the stability of the C-F bond. Unlike the PFAS of original concern, i.e. PFOA (Perfluorooctanoic acid) and PFOS (Perfluorooctanesulfonic acid), many of these shorter chain PFAS and other fluorinated by-products are likely to be fat soluble, not water soluble, and will accumulate in human body fat and will be passed to the fetus during pregnancy.

Yu et al, 2020 (cited above), identified some of the following fluorinated by-products in the pyrolysis of spent lithium-ion batteries. They reported the detection of 1,4-difluorobenzene, 1,2,4-trifluorobenzene, and 1,3,5-trifluorobenzene.

Yu et al. also cited by-products reported by other researchers:

- Choi and Kim (2012) reported the major products of PVDF pyrolysis as vinylidene fluoride (VDF), 1,3,5-TriFluoroBenzene, 1,4-DiFluoroBenzene, 1,2,4-TriFluoroBenzene, and 1,3,3,5,5-pentafluorocyclohexene. *Note: Vinylidene fluoride contains a reactive C = C double bond and is likely to form many other fluorinated compounds during heating and burning, including PFAS.*

- O'Shea et al. (1990) reported that increasing pyrolysis temperature resulted in a complex degradation process and a pyrolytic residue made up of largely aliphatic and fluoro-aromatic structures. *Note: "aliphatic fluoro-compounds" would almost certainly include PFAS.*

- Zulfiqar et al. (1994) reported that the major degraded products of PVDF were HF, VDF (vinylidene di fluoride – the monomer), and C4H3F3. *Note: the latter substance is a PFAS.*

What is important to note here is that of this list of by-products only HF would be removed by the air pollution control devices proposed for SungEel's Endicott facility, **because most of the fluorinated by-products are likely to be insoluble in water and will not be removed using a wet scrubber.**

Moreover, none of this research discussed above has investigated further by-products that might be produced in an afterburner. Starting with fluorinated benzenes the possibilities included fluorinated dioxins and furans (PFDDs and PFDFs), and polyfluorinated biphenyls (PFBs). None of these were investigated in the single test performed at the SungEel faciity in South Korea even though they could pose grave toxic hazards if released into the environment.

We need verifiable scientific emission data from SungEel's South Korean facility

Clearly, the onus is on SungEel to provide empirical evidence as to what products are formed during processing the whole range of lithium-ion batteries in their South Korean facility, which they claim to have operated "safely and cleanly" for over 10 years. Unfortunately, up to this point such claims have not been backed up with verifiable scientific data. It should be stressed that aside from HF, not one of the hazardous fluorinated compounds discussed above was investigated by those monitoring the facility in South Korea.

Nanoparticle Concerns

Nanoparticles generated by the proposed facility are yet another concern that New York State has failed to address.

Jens Tubke, 2019, writes, "The decomposition of the cathode material can be accompanied by phase changes at higher temperatures leading to the formation of nanoparticles of metal oxides (e.g., NiO, CoO, MnO) and metals (e.g., Ni, Co)… These particles are then present in the smoke and dust ejected from the cell and pose a health risk as well."

It is important to stress that these nanoparticles are so small that a) they would not be captured in the baghouse used by SungEel and b) and once released into the ambient air are able to pass through the membranes of the lung, enter the bloodstream and reach every tissue in the body.

The health consequences of these nanoparticle emissions are profound. For example, a strong correlation has been documented between nanoparticles in the ambient air and an increase in brain cancer in Montreal. Researchers found that a one-year exposure to a concentration of 10,000 nanoparticles (that is about one billionth of a gram) in one cubic centimeter of ambient air was related to a 10% increase in brain cancer (Weichenthal et al., 2020).

While the DEC does not require the monitoring of nanoparticles in incinerator emissions, we request that you require a comprehensive air pollution control standard to be adopted prior to granting any air discharge permit for this-first-of-its-kind facility in the USA. This new standard must include baseline community air quality monitoring to make sure that no degradation of existing air quality occurs.

We are additionally concerned that your agency, the Empire State Development is providing SungEel $1.75 million in support of this project. Communities in the southern tier have much better uses for this money and we recommend that it not go to support this dangerous project but instead be offered to local governments who are struggling due to the impacts of Coronavirus.

Conclusion

We trust that you will find our request self-explanatory, but please do not hesitate to get in touch with us if you have any questions or suggestions. We can be reached at pconnett@gmail.com and jjruspantini@nptusa.org and also by phone at 607-217-5350 (Paul) and 607-206-8312 (John).

The hallmark of your administration's efforts to safeguard public health and the environment throughout New York's Southern Tier was your decision to adopt a moratorium on high-volume, hydraulic shale fracking until New York completed a comprehensive environmental review of that extraction process. Ultimately, your administration determined that it could not be done safely and adopted a statewide prohibition of the practice.

We request that you now require an equally protective review process for the proposed lithium-ion battery processing facility because we believe New York must not permit the facility to be built and operated until all PFAS and other toxic chemical concerns have been fully resolved.

In conclusion, Endicott, NY has inherited a legacy of toxic contamination hazards that New York environmental and public health authorities have failed to clean up for literally decades in strict compliance with applicable regulatory requirements.

We understand the importance of recycling lithium-ion batteries and support sustainable practices to reduce waste and conserve resources. However, it would be utterly irresponsible to exacerbate Endicott's pollution hazards with PFAS and other contamination threats, by allowing this particular form of recycling lithium-ion batteries into the community. We believe there is widespread support for this sensible policy approach throughout Endicott and request that you implement it.

Thank you for your consideration.

Sincerely,

Paul Connett, PhD

John J. Ruspantini, CHMM, PMP

Cc:

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References

Chen X, Zhou T. 2014. Hydrometallurgical process for the recovery of metal values from spent lithium-ion batteries in citric acid media. Waste Manag Res 32(11):1083–1093.

Cheng S, et al. 2019. Effects of Ca and Na acetates on nitrogen transformation during sewage sludge pyrolysis. Proc Combust Inst 37(3):2715–2722.

Choi S, Kim Y. 2012. Microstructural analysis of poly (vinylidene fluoride) using benzene derivative pyrolysis products. J Anal Appl Pyrolysis 96:16–23.

Duan C et al. 2018. Rapid synthesis of hierarchically structured multifunctional metal-organic zeolites with enhanced volatile organic compounds adsorption capacity. Ind Eng Chem Res 57(45):15385–15394.

Gao W, et al. 2018. Comprehensive evaluation on effective leaching of critical metals from spent lithium-ion batteries. Waste Manag 75:477–485.

Larsson, et al. 2017. Toxic fluoride gas emissions from lithium-ion battery fires Nature Scientific Reports volume 7, Article number: 10018 (2017). https://www.nature.com/articles/s41598-017-09784-z.

Mossali et al. 2020. Lithium-ion batteries towards circular economy: A literature review of opportunities and issues of recycling treatments. Journal of Environmental Management: Volume 264, 15 June 2020, 110500. https://www.sciencedirect.com/science/article/pii/S0301479720304345

Natarajan S, Aravindan V. 2018. Recycling strategies for spent Li-ion battery mixed cathodes. ACS Energy Letters 3(9):2101–2103.

O'Shea ML et al. 1990. Spectroscopic studies of carbons. XVII Pyrolysis of polyvinylidene fluoride. Mater Chem Phys 26(2): 193–209.

Phelps L. 2020. USEPA PFAS Thermal Treatment & Methods Research - Opportunities for Collaborative Incineration Field Testing (April 27, 2020).

Qi W. et al. 2019. An efficient magnetic carbon-based solid acid treatment for corncob saccharification with high selectivity for xylose and enhanced enzymatic digestibility. Green Chem 21(6):1292–1304.

Tubke et al. 2019. *Electrochemical Power Sources: Fundamentals, Systems, and Applications, 2019.*

Wang F, et al. 2018. Recovery of valuable materials from spent lithium-ion batteries by mechanical separation and thermal treatment. J Clean Prod 185:646–652.

Wang M, Tan Q, Liu L, Li J. 2019a. A low-toxicity and high-efficiency deep eutectic solvent for the separation of aluminum foil and cathode materials from spent lithium-ion batteries. J Hazard Mater 380:120846.

Wang M, Tan Q, Liu L, Li J. 2019b. Efficient separation of aluminum foil and cathode materials from spent lithium-ion batteries using a low-temperature molten salt. ACS Sustain Chem Eng 7:8287–8294.

Weichenthal et al. 2020. Within-city Spatial Variations in Ambient Ultrafine Particle Concentrations and Incident Brain Tumors in Adults. Epidemiology. 31 (2), 177-181. https://journals.lww.com/epidem/Fulltext/2020/03000/Within_city_Spatial_Variations_in_Ambi ent.4.aspx

Xiao J, Li J, Xu Z. 2017. Novel approach for in situ recovery of lithium carbonate from spent lithium ion batteries using vacuum metallurgy. Environmental Science & Technology 51(20):11960–11966.

Xiao J, Li J, Xu Z. 2020. Challenges to future development of spent lithium ion batteries recovery from environmental and technological perspectives. Environmental Science & Technology 54(1):9–25.

Yu et al. 2020. Pyrolysis characteristics of cathode from spent lithium-ion batteries using advanced TG-FTIR-GC/MS analysis. https://link.springer.com/article/10.1007/s11356-020-10108-4

Zeng X, Li J. 2014. Innovative application of ionic liquid to separate Al and cathode materials from spent high-power lithium-ion batteries. J Hazard Mater 271:50–56.

Zulfiqar S et al. 1994. Study of the thermal degradation of polychlorotrifluoroethylene, poly (vinylidene fluoride) and copolymers of chlorotrifluoroethylene and vinylidene fluoride. Polym Degrad Stab 43(3):423–430.