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PFAS and other compounds in solar panels, wiring, and coatings

Renewable energy should offer more than promises that it is good for the environment. The solar industry promotes photovoltaic (PV) technology in the most wholesome terms: generating clean, free power from the sun. This benevolent assessment potentially omits environmental impacts during the manufacturing, operational lifetime, and disposal of solar panels and battery storage systems. Host towns need proof, not simply promises, when evaluating how solar projects may affect their residents and environment, both now and in the future.

Introduction

In July 2021, the Town of Avon, New York adopted Local Law 3 of 2021. This precedent-setting amendment to the local solar law prohibits using solar panels that "utilize or contain any amount of GenX chemicals or polyfluoroalkyl (PFAS) substances."[1] This position aligns with state and federal laws protecting our water supply. For the long-term safety of Coxsackie residents, Hecate Energy (Hecate) and its successors should agree to a Certificate condition that prior to construction, Hecate will provide documentation verifying that the solar panels and associated electrical equipment used to construct the Greene County Solar Facility (the Facility) do not contain per- and polyfluoroalkyl substances (PFAS), including PFOA, PFOS, and GenX chemicals.

[1] https://www.avon-ny.org/PDFs--Town%20Clerk/ll3-2021.pdf

We would like to believe that Hecate's commitment to our town's public health and safety, as well as their desire to avoid potential future liability, would encourage them to give these comments careful consideration. Hecate must rely on manufacturers' data, which may not be fully transparent for solar panels and lithium-ion batteries, especially when they are manufactured outside of the United States—in this case often in China.

This Certificate condition would help safeguard our soil, surface waters, and groundwater from potential contamination. While such protection would help protect Sleepy Hollow's water supply, it provides important safeguards for all residents living in the vicinity of the Facility. Hecate and the Town of Coxsackie should perform pre- and post-installation soil and water testing, with annual monitoring. In addition, the installer should fund an escrow account for the Town to hire an independent, certified third-party laboratory for soil and water testing.

PFAS and related compounds

According to the National Institute of Environmental Health Sciences, perfluoroalkyl and polyfluoroalkyl substances (PFAS) are toxic, persistent, and bioaccumulative.[2] These synthetic fluorochemicals were first developed in the 1930s and have strong carbon-flourine bonds that make the structure repel both oil and water.[3] The Green Science Policy Institute details that these manmade chemicals are widely used in building materials such as paints, cleaning products, non-stick coatings, sealants, tapes, wire coverings, glass, solar panels, and batteries.[4] PFAS is commonly found in foam used to extinguish electrical fires.[5]

These "forever chemicals" have been linked to cancer and other health issues. Certain PFAS do not break down easily, causing them to remain indefinitely in the soil and water. Their potential hazard and persistence in the environment may pose a cumulative danger to public health. PFAS comprise a group of compounds, including PFOA, PFOS and GenX chemicals. The United States Environmental Protection Agency (EPA) has

[2] https://www.niehs.nih.gov/health/topics/agents/pfc/index.cfm

[3] https://www.nature.com/articles/d41586-019-00441-1

[4] https://greensciencepolicy.org/docs/pfas-building-materials-2021.pdf

[5] https://www.gao.gov/assets/gao-21-421.pdf

identified that the potentially toxic and carcinogenic nature of many of these chemicals demands careful evaluation.[6, 7]

The disposal of PFAS-containing materials is problematic, as evidenced by the recent cleanup and lawsuits filed against Noralite Hazardous Waste Facility in Cohoes, New York.[8] In July 2021, the village of Hoosick Falls reached a $65 million settlement with Saint-Gobain, Honeywell International, 3M, and DuPont for PFOA contamination of their groundwater that affected at least 544 private wells.[9] Unfortunately the water remains contaminated, and the plant that used PFOA chemicals has been declared a Superfund site.

PFAS legislation in New York State

In 2016, the NYS Department of Environmental Conservation (DEC) issued a regulatory impact statement to 6 NYCRR Part 597 adding PFOA and PFOS as hazardous substances. This ruling was adopted by the DEC in March 2017.[10] In July 2020, NYS passed S.8817 and A.4739-C, which ban the use of PFAS in food packaging.[11] And in August 2020, the NYS Department of Public Health (DPH) voted to set the maximum contaminant levels (MCLs) at 10 parts per trillion (10 ppt) for both PFOA and PFOS in our drinking water supply.[12] NYS legislation permits the DPH to require that public water systems are tested for the contaminants and ensure that elevated levels are addressed.[13]

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[6] https://www.epa.gov/pfas/basic-information-pfas

[7] https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-and-polyfluoroalkyl-substances-pfas

[8] https://www.wamc.org/capital-region-news/2020-06-25/cohoes-residents-file-intent-to-sue-norlite-over-burning-firefighting-foam

[9] https://pfasproject.com/hoosick-falls-new-york/

[10] https://www.dec.ny.gov/regulations/104968.html

[11] https://www.nysenate.gov/legislation/bills/2019/s8817

[12] https://www.health.ny.gov/environmental/water/drinking/docs/water_supplier_fact_sheet_new_mcls.pdf

[13] https://news.bloomberglaw.com/environment-and-energy/new-york-moves-on-some-of-strictest-pfas-drinking-water-limits

PFAS legislation in other states

North Carolina is among the top three states for solar development. By February 2018, residents and the state were questioning the presence of PFAS in solar panels.[14] *The North Carolina State Journal* reported that EPA physical scientist Dr. Mark J. Strynar provided 39 records from the SciFinder database used by the EPA to identify applications of PFAS with solar panels.[15] In August 2018, *The Carolina Journal* reported that the EPA confirmed that PFAS are used in solar panel production.[16] While studies may not be conclusive, the lack of definitive conclusions and transparency raises concerns.

In December 2020, Marc Fitch of the Yankee Institute reported that the Connecticut Department for Health was concerned about PFAS in solar panels.[17] "We've asked the question, have received some information, and have also received some push-back when we ask those questions about whether these panels contain PFAS and different PFAS chemicals." It is the lack of answers and documentation that is troubling and raises questions of the long term impact of solar panels and battery storage on our soils and drinking water.

PFAS Federal legislation

Federal regulations surrounding PFAS are being adopted rapidly, and further restrictions at the national level are expected. US Representative Debbie Dingell (D-MI-12) sponsored Bill H.R.2467, PFAS Action Act of 2021, to "establish requirements and incentives to limit the use of perfluoroalkyl and polyfluoroalkyl substances, commonly referred to as PFAS, and remediate PFAS in the environment."[18] The Bill passed the House July 21, 2021 and is awaiting a vote in the Senate.[19] The Executive Office of the President and other advocacy groups such as Consumer Reports support passage of the

[14] https://nsjonline.com/article/2018/02/solar-panels-could-be-a-source-of-genx-and-other-perflourinated-contaminants/

[15] https://nsjonline.com/wp-content/uploads/2018/02/perfluoro-and-solar-panels-Reference_02_15_2018_120238-002.pdf

[16] https://www.carolinajournal.com/news-article/epa-confirms-genx-related-compounds-used-in-solar-panels/

[17] https://yankeeinstitute.org/2020/12/03/department-of-public-health-concerned-about-pfas-in-solar-panels-near-drinking-water/

[18] https://debbiedingell.house.gov/news/documentsingle.aspx?DocumentID=2975

[19] https://www.congress.gov/bill/117th-congress/house-bill/2467

Bill. [20, 21] Additionally, the Environmental Protection Agency (EPA) proposes reporting and record-keeping requirements for PFAS under the Toxic Substances Control Act (TSCA).[22]

The August 3, 2021, *National Law Review* included an article by John Gardella of CMBG3 Law in Boston. He concludes that while the US Senate vote has not been determined, that "the pressure is on the EPA to take regulatory action well beyond just drinking water, and companies absolutely must begin preparing now for regulatory actions that will have significant financial impacts down the road."[23]

PFAS in solar panel and battery manufacturing

Despite industry and a few academic assurances to the contrary, broad research consistently indicates that PFAS chemicals are used in solar panel and battery manufacturing and installation. PFAS is found in the coatings on electrical wires, backing panels, tapes, and adhesives.

Of particular concern is the use of PFAS in anti-reflective coatings (ARC) and anti-soil coatings (ASC) that are used to increase solar panel productivity. Material and Data Safety Sheets detail the contents of products manufactured in the United States. However, at this time, China is the major supplier of polysilicon[24] solar panels and batteries.[25] Accountability and transparency for materials and products made outside of the United States is questionable. In June 2021, the Biden administration banned import and use of certain solar energy materials and products from China due to the country's use of forced labor and genocide at polysilicon mines.[26]

Two types of solar panel coatings are commonly used: anti-reflective coatings (ARC) and anti-soil coatings (ASC)

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[20] https://www.whitehouse.gov/wp-content/uploads/2021/07/HR2467.SAP-Final.docx.pdf?source=email

[21] https://advocacy.consumerreports.org/press_release/house-votes-to-approve-the-pfas-action-act-hr-2467/

[22] https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-and-polyfluoroalkyl-substances-pfas

[23] https://www.natlawreview.com/article/congress-presses-forward-pfas-measures

[24] https://www.solarpowerworldonline.com/2021/05/no-avoiding-it-now-soon-the-top-4-polysilicon-manufacturers-will-be-based-in-china/

[25] https://www.forbes.com/sites/rrapier/2019/08/04/why-china-is-dominating-lithium-ion-battery-production/?sh=770793d23786

[26] https://www.ecowatch.com/china-solar-panels-ban-biden-2654961710.html

Anti-Reflective Coating (ARC)

A bare silicon glass surface may have a reflection index of more than 30%.[27] Anti-reflective coatings (ARC) are used to increase solar panel productivity by adding a dielectric coating on the glass surface. This coating textures the glass surface, which results in specific bands of wave lengths to be trapped inside the panel where they can generate additional electricity by coming in contact with the photovoltaic cells.

In their Application Appendix 15-A: Glare Analysis, Hecate Energy states that the panels they expect to use will have an anti-reflective coating, presumably to increase efficiency.

Anti-Soil Coating (ASC)

Dust and dirt can foul the panel surface and hinder the conversion of light to electricity. To maintain steady performance, the panel's surface must be cleaned regularly. Current manual or robotic cleaning methods are expensive and inefficient.

The hydrophobic qualities of ASCs create a non-stick surface that promotes water shedding, resulting in "self-cleaning'" solar panels. This coating is applied to the front facing glass surface at the time of manufacture. The water-repelling surface promotes water cohesions, allowing the water droplets to form fully with minimal surface contact. This enhances water droplet shedding and in the process removes dust and dirt from the surface of the panel. ASCs help decrease maintenance costs while increasing the electricity generated. It can be reapplied in the field with products such as 3M AS Liquid 600.[28]

ASC is typically manufactured with either silicon dioxide (SiO2) or titanium dioxide (TiO2) nanoparticles combined with long chains of fluoropolymers. While SiO2 may be inexpensive it is less durable to environmental elements. TiO2 appears to be more stable and is reported to be more frequently used for solar panel ASC.

There are increasing concerns about the negative impact of TiO2 on the environment and human health. In December 2020, California announced the review of titanium dioxide nanoparticle classification under their Safe Water Act Proposition 65.[29]

Gohar Dar's book *TiO2 Nanoparticles,* published in February 2020, includes a chapter on "Toxicity of TiO2 Nanoparticle". This research indicates that lung tumors are found in

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[27] https://www.pveducation.org/pvcdrom/design-of-silicon-cells/anti-reflection-coatings

[28] https://www.coatingsworld.com/issues/2012-10/view_paint-amp-coatings-manufacturer-news/3m-rolls-out-pv-anti-soiling-coating/

[29] https://www.paintsquare.com/news/?fuseaction=view&id=23184

mice that have had long term exposure to TiO2.[30] Chapter 2: "Applications in Nanobiotechnology and Nanomedicine" research indicates safety concerns regarding TiO2 nanoparticles on aquatic species.[31]

While the potential for titanium dioxide nanoparticles to contaminate our soils is not conclusive, the possibility warrants further investigation. The evidence appears to be mounting, and the developer should carry the burden of proof.

Research papers call for caution and further study of ARC and ACS on solar panels. Natatajan Shanmugam's May 2020 study "Anti-Reflective Coating Materials: A Holistic Review from PV Perspective,"[32] published in *Energies,* provides a 98-page comprehensive report. On page 67 the author states: "The implementation of ARCs on the solar cell would suppress the reflection, and in turn, enhances the PCE, [power conversion efficiency] but their durability with continuous exposure to the environment and performance degradation characteristics are some novel areas where research is required."

ARC and ASC resist some stresses, but not others:

> [T]he coatings may resist the harsh environmental stresses such as damp heat and humidity freeze, but they are susceptible to damage under UV exposure. XPS analysis revealed a clear reduction in fluorine in the composition of the coating after exposure to UV and outdoor testing. [33]

Kenan Isbilir's 2019 thesis at Loughborough University studies the "performance and durability of anti-reflective and anti-soiling coatings on solar cover glass"[34] His thesis investigated the durability of commercially available two types of single layer (ARC1 and ARC2) and one multilayer anti-reflective (MAR) commercially available coatings, as well as ASCs. After testing several coatings, he concludes that:

> The durability of these coatings against UV light and abrasion resistance would need to be improved if they are to be applied to PV cover glass.

In 2020, Gizelle C. Oehler found that certain ASC break down in as little as two weeks:

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[30] https://onlinelibrary.wiley.com/doi/abs/10.1002/9783527825431.ch2

[31] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3720578/

[32] https://www.researchgate.net/publication/341556138_Anti-Reflective_Coating_Materials_A_Holistic_Review_from_PV_Perspective

[33] https://www.researchgate.net/publication/329506058_Testing_of_an_Anti-Soiling_Coating_for_PV_Module_Cover_Glass

[34] https://repository.lboro.ac.uk/articles/thesis/The_performance_and_durability_of_anti-reflective_and_anti-soiling_coatings_on_solar_cover_glass/8132048/1

> Surprisingly, the coatings began to degrade quickly, and the effect was clear after only two weeks of exposure. Degradation resulted in decreasing water contact angle and increasing roll-off angles. As observed by Bhaduri et al., the degradation was much faster than anticipated because the outdoor environment combines the stresses tested in the laboratory [31]. Degradation was caused by a number of mechanisms including solvent release, fluorine loss, thinning of the coating, and increasing surface macro-roughness. [35]

The location or accumulated amounts of the degraded chemicals is not discussed in these studies. It is logical to assume that the chemicals sloughing off with the rainwater are deposited into the underlying soil, groundwater and aquifers. The cumulative effect of tens of thousands of solar panels for 35 or more years would most likely permanently contaminate the site's groundwater, soil, and stormwater runoff. If coatings are reapplied during the projects lifetime then additional concerns are raised. How is the ground protected during reapplication? How often is the coating reapplied to the panels on site? Improper disposal of broken and decommissioned solar panels may permanently contaminate landfills and any nearby aquifers. If regulations continue to become more restrictive, how will the panels be disposed of, and is the decommissioning fund adequate?

Millions upon millions of solar panels will be used and disposed of within New York State during the next two decades. Periodic upgrades and damage or defects will need to be addressed long before the end of the project's life.[36] Developers should carry the burden of proof that their materials and products do not contain PFAS. Towns and taxpayers should trust but verify all materials provided by the developers. The people cannot afford the risk that solar panels and storage batteries may contaminate our drinking water and soil, either upon installation, during use, or during disposal. It seems doubtful that developers' required liability coverage would be sufficient for a large-scale PFAS cleanup project.

In June 2021, Niagara County adopted an Extended Producer Responsibility (EPR) law to protect their landfills from being overburdened by the disposal of solar panel waste. The law requires "producers of solar panels sold in the county to finance and manage their safe reuse and recycling when decommissioned."[37] Phone calls to Greene and Columbia county landfills have not provided confirmation that they will accept large quantities of solar panels, either today or in the future. One company suggested contacting We Recycle Solar, which is located in Arizona. State and federal laws for PFAS are

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[35] https://repository.lboro.ac.uk/articles/journal_contribution/Testing_the_durability_of_anti-soiling_coatings_for_solar_cover_glass_by_outdoor_exposure_in_Denmark/11558853

[36] https://hbr.org/2021/06/the-dark-side-of-solar-power

[37] https://www.productstewardship.us/news/571089/Niagara-County-Passes-Nations-2nd-Solar-Panel-Producer-Responsibility-Law.htm

likely to become more numerous and stringent. The town and county should consider the possibility of PFAS contamination from solar panels deposited in our local landfills and require developers to prove that their installations will not include products containing PFAS.

Industry Response

Manufacturers of ARC and ASC may understand the environmental concerns and toxicity risks of their products. A few companies are beginning to provide non-toxic coatings. One company's solution is a proprietary nanoparticle coating that is an environmentally friendly.

> WattGlass has addressed and overcome many of the issues typical of other antireflective coatings (ARCs): things such as toxicity, shelf life, and durability. WattGlass is happy to offer a non-toxic, water based, long shelf-life solution to existing ARC technologies that is easily implemented as a drop in replacement.[38]

> Solar ARC surpasses the performance of conventional coatings and is resistant to particulate soiling while remaining non-hazardous and 100% water-based. Typically, these coatings result in tradeoffs between performance and functionality and utilize hazardous materials such as solvents, acids, and fluorocarbons. Not with WattGlass.

If Watt Glass feels it is important to stress their environmentally friendly non-fluorocarbon solution again and again, it raises the obvious question: what are the other companies using, and how might their products harm our soil, water, and public health?

What's next

On August 19, 2021, OxyChem announced that it was closing its Niagara Falls plant, the site of America's first major environmental disaster, Love Canal. In 1988, NYS Department of Health Commissioner David Axelrod called the Love Canal incident a "national symbol of failure to exercise a sense of concern for future generations."[39]

Solar energy resources are marketed as an environmentally-friendly way to generate electricity. However, research indicates that solar panels, coatings, wire coverings, tapes, adhesives and batteries contain PFAS that may permanently harm our soils and poison our drinking water.

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[38] https://www.wattglass.com/technology

[39] https://www.nytimes.com/1988/08/05/nyregion/after-10-years-the-trauma-of-love-canal-continues.html

An October 2020 Bloomberg Law article provides insight into upcoming PFAS regulations in relation to the Development of renewable energy in New York State.

> Overall, along with the CLCPA, the new Siting Law and the expected PFAS regulations fundamentally change long-standing environmental paradigms in New York State. The flurry of regulations expected from Albany in the next few years will usher in a new era of environmental regulation quite different from today. Those well prepared for the transition will be positioned to prosper from it, while those who are not will fall behind or find their business plans or goals outdated or not fully achievable.[40]

Conclusions

Renewable energy developers are responsible to their investors. Not the town. Not the neighbors. And not the environment. Solar projects are held by individual LLCs whose only asset may be an aging infrastructure built on leased ground. At time of decommissioning—or evidence of contaminants—it is unlikely that there will be a deep-pocketed corporation to bring the site into compliance with current or future EPA and DEC standards.

The July 2021 ruling on the Fieldwood Energy, LLC bankruptcy case sets precedent that previous oil well owners, and the insurance companies that issue them bonds, are responsible for the cleanup cost of wells.[41] Insurance company trends with oil and gas may become the standards for the renewable energy sector, making it difficult and costly to insure solar power plants.

Prior to construction, Hecate Energy should be held responsible to neighboring residents and Coxsackie's municipal government by providing documentation that the solar panels, coatings, and electrical infrastructure specified for the project do not contain PFAS or other toxic chemicals. Attempting to remedy a "forever chemical" such as PFAS contamination over more than a thousand acres of solar coverage would likely be impossible.

While there are a few alternative options that may be safer, these products are more expensive and are manufactured in smaller quantities. Utility-scale solar power plants require hundreds of thousands, if not millions, of photovoltaic panels at the time of installation. The ability to manufacture and deliver this quantity is limited to the very largest

[40] https://news.bloomberglaw.com/environment-and-energy/impact-of-new-yorks-renewable-energy-permitting-program-pfas-regulation

[41] https://www.bondexchange.com/oil-industry-woes-lead-to-massive-changes-in-the-insurance-industry/

suppliers, most of them based in China, where Material Data and Safety Sheets are limited and if provided the information is questionable.

Reputable solar panel manufacturing companies that freely provide Material Data and Safety Sheets may be limited. Solar developers that provide toxicity guarantees on their panels being free of dangerous chemicals may be even fewer. While the level of toxicity of ARC and ASC may lack clarity, the coatings' exposure to the elements and where the sloughed-off chemicals will be deposited is not. The chemicals are likely to enter the soil and groundwater.

When reviewing this Application, the Siting Board must not rely on good intentions. As has been noted throughout this proceeding, multiple solar projects will be constructed in the watershed of Sleepy Hollow Lake. Measures should be taken to determine that panels, electrical infrastructure, and wiring for these projects is PFAS-free.

What we are discussing here is a matter of public health and safety, we encourage the Board to require developers to provide specification sheets, and to describe preventive measures, testing policies, and Material and Data Safety Sheets in order to protect Coxsackie public health and to protect the town from future liability. Preventative measures—not after-the-fact remediation—are the answer to avoiding PFAS contamination of soil, stormwater runoff, drinking water, and aquifers surrounding the project.