Maryland's Grid-of-the-Future

Draft White Paper on Goals and Principles to Guide the Creation of an Affordable, Equitable, Democratic, Reliable, Clean Energy System

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Introduction: Building Maryland's Grid-of-the-Future

We are at a historic juncture in the electricity system that has rightly been compared to the one in which the communications system found itself 30 years ago. The economic and environmental stakes are bigger this time. This working draft of a white paper on Maryland's grid-of-the-future (GOTF) aims to open dialogue in our state on the broad array of issues that are inherent in the changes that will take place as the electricity system is transformed. Our goal is to set forth the issues that seem essential to ensuring that the principles on which the GOTF will be created are sound and promote energy democracy and equity, while ensuring reliability, affordability, resiliency, and, in the longer term, low to zero pollution and emissions.

Today's electricity system consists almost entirely of large generating stations; the electricity generated there is brought by high voltage transmission lines to population centers and in turn distributed at low voltages to homes and businesses. Each element of this system is highly capital intensive and centralized, making choice in electricity supply very limited. The vast majority of generation uses fossil fuels and consumes large amounts of cooling water; this puts much of electricity generation water needs in direct competition with agriculture, other industries and domestic water supply. The advent of solar energy, which is economical at much smaller scales and can even be put on the rooftops of individual homes and other buildings, holds the promise of changing all of that. Decentralized solar energy can be complemented by storage, demand response, and wind energy. Solar and wind energy are Maryland's main renewable energy resources.

Wind and solar energy offer numerous environmental benefits: there is no pollution at the point of generation, they are entirely renewable, produce no CO2 emissions, and consume essentially no water. And the expansion of small-scale solar and other distributed resources like storage means that millions of consumers could become producers of electricity and suppliers of electricity services as well. There is even a new word for such producer consumers: prosumers. For these and other reasons, the GOTF will look very different in structure from the present centralized system.

The Maryland Public Service Commission has indicated (in the context of the proposed Exelon-PHI merger) that a regulatory proceeding to facilitate the deployment and integration of renewable and distributed energy resources would be desirable. Proceedings currently underway in California, Hawaii, and New York are taking on a broad approach to facilitate the transition to a responsive, resilient, low-/zero-carbon, renewable energy-based electricity system, incorporating distributed and customer-owned generation resources. GOTF proceedings in those states are addressing the large technical, structural, economic, and regulatory reforms involved in modernizing the electricity transmission and distribution system to integrate high levels of renewables and eliminate greenhouse gas emissions. These proceedings could hold important lessons for Maryland as we consider the GOTF that would meet the needs of the state's people, economy, and environment including a transition to a responsive, resilient, distributed, low-/zero-carbon, renewable energy-based electricity system.

Further, the GOTF will have to accommodate to more stringent standards. The present centralized system works reasonably well in normal times; yet, recent events like the June 2012 derecho in the mid-Atlantic region or Hurricane Sandy later that year have shown that it is not robust or resilient enough in the face of extreme weather events -- and climate change means we must plan for that.

Finally, conflicts between paying energy bills and paying the rent or buying food and medicine all too common for low income households today; they have devastating results for thousands of families. The prospective transformations in the electricity sector could make present inequities worse or improve them structurally. The transition to a GOTF must be equitable for low-income households that currently bear the highest energy burdens (financial, social, and environmental), providing them with the same choices as others and ensuring affordability.

A GOTF that meets such demanding goals in the context of a major technical and economic transformation of the energy system will require a set of principles to undergird it. To that end, several organizations have come together to convene a broad base of advocates, constituency groups, and stakeholders to begin developing those principles for the GOTF. We offer this draft white paper as a starting point for dialogue, to organize a range of ideas from various constituencies into one place, and to stimulate the imaginations of those participating in the summit.

The paper begins with an overarching goal for Maryland's GOTF, and articulates a set of eight principles to guide the development and implementation of PSC regulations to achieve that goal. The ideas presented here are not intended to be an end product; rather this paper is a draft intended to solicit comments on both the overall goal and the principles. We expect to engage in a process to that we hope will result in a common set of principles for advocacy based on the GOTF conference and future convenings of stakeholders.

Overall Goal: To achieve an affordable, just, democratized, resilient, and emissions-free electricity sector.

The success of any Maryland Grid-of-the-Future proceeding will be measured by whether it advances a socially just and environmentally sustainable transformation of the energy system. The goals include affordability, social and economic equity, access, reliability, energy democracy, and resilience in the context of achieving decarbonization of the grid. The reduction of other forms of pollution, such as air pollution and upstream environmental damage should also be important considerations. These are complex and difficult goals; ensuring their achievement will require that the development of the GOTF be guided by an explicit set of principles, which we discuss below,

Principles to Guide the GOTF

1. Affordable: Ensures that energy services are affordable to all Marylanders

Energy costs are already a significant economic burden for hundreds of thousands of families in Maryland. Over 700,000 households -- about one-third of the total -- would be eligible for heating bill assistance under the broadest federal criteria, though only half of them are under Maryland rules. At the average level of income, household energy bills are 3 or 4 percent of income. At the poverty level, they can be 10 or 15 percent. At 50 percent of poverty level, the energy burdens rise to 40 percent of income, creating severe food-fuel-rent-medicine conflicts. Low-income households just cannot afford higher energy costs.

A low-emissions grid of the future that is also resilient will likely have an electricity cost and rate structure that is quite different than today. It is essential that energy become more affordable for low-income households as we move to the grid of the future. This will mean attention to the structure of rates, ensuring that low-income households have the choices and opportunities to manage their bills, and designing assistance programs so that they enhance energy security and affordability during and after the transition to a GOTF.

In any case, the number of low-income households is so large that unless they participate in the opportunities in full measure, achieving a resilient and emissions-free electricity system will be essentially impossible. On the positive side, policies that make renewable energy, resilience, and efficiency more accessible and affordable will not only help the environment and economy but could also help redress some of the more intractable inequities in society. Energy affordability must be central to the GOTF.

2. Clean: CO2 Emissions-free and low pollution, including low-upstream impacts

In order to do our part to mitigate climate change and be among the leading states, Maryland must achieve the goal of deep greenhouse gas emission reductions by 2050 set forth in the 2009 Greenhouse Gas Reduction Act. A transition to a GOTF must aim for an emissions-free electricity sector by 2050 at the latest. We note that emission reductions made earlier have a larger beneficial impact compared to the same reductions made later. Maryland is at particular risk from climate change because sea-level rise, increasingly severe storms threaten the habitability, economy, and infrastructure of much of the state, including the Chesapeake Bay region. The impacts of climate change will be widespread, with the potential to worsen many other social and economic problems Maryland confronts including economic inequality, public health disparities and environmental injustice.

While climate change is one of the most immediate environmental issues Maryland must address, it is not the only one. Air pollution, caused largely by fossil fuel use, notably by power plants and in transportation, is a major cause of ill-health and environmental injustice. Use of fossil fuels also has severe upstream impacts, like mountaintop removal and water pollution. The adverse health and environmental impacts due to the production and refining of uranium for nuclear fuel continue to this day, as for instance on Native American lands in the Southwest as well as in other countries. The storage and management of radioactive waste generated by nuclear power plants is a persistent risk to the Chesapeake Bay; if moved, it would also entails significant environmental and health risks. Extensive water use by thermal generation creates conflicts with other uses, and also reduces the margins available to address ecological problems afflicting the Chesapeake Bay. Thermal generation (mainly coal and nuclear) is the top user of water in the Susquehanna River basin; the river feeds fresh water to the Bay. Coal and uranium mill tailings ponds present hazards to people and water systems. Upstream methane leaks in other states are a major issue for climate change; Maryland does not yet include them in its greenhouse gas accounting, but it is important that it do so.

We recognize that there is no completely clean energy source on a lifecycle basis because the manufacture of the components of all energy sources, whether they be solar panels or wind turbines or coal and nuclear plants, involves the use of polluting energy sources and transportation. But certain energy sources, notably wind and solar, do not require fuels. Once they are in place, they produce no air, water, or soil pollution or CO2; they require no mining, and use essentially no water. A renewable energy system would eliminate upstream CO2 and ‘other pollution as well. This is in contrast to energy sources like coal and nuclear that by their nature produce dangerous wastes (like nuclear spent fuel and coal ash ponds and fracking wastewater), require mining of fuels, use vast amounts of water for their operation, and are by their nature not renewable.[1]

The GOTF should aim to achieve its goals by relying as completely as possible on renewable energy and efficiency used with minimal upstream impacts, including mining and manufacturing impacts on air, soil, and water. Given the disasters created by coal ash pond dam breaks, by a huge uranium mill tailings dam break (in New Mexico), and by the decades-long failure to solve the radioactive waste problem, despite the expenditure of billions of dollars, it is important for the GOTF to include potential backend impacts when designing the mix of generation sources and materials to be used.

3. Socially Just: Responsibly supports workers and communities affected by the transition to a clean energy economy.

The transition to a clean energy economy will be overwhelmingly positive for Maryland overall, creating economic opportunity, making communities healthier, cleaning up our air and water,

[1] According to the Intergovernmental Panel on Climate Change “[r]enewable energy is obtained from the continuing or repetitive currents of energy occurring in the natural environment and includes non-carbon technologies such as solar energy, hydropower, wind, tide and waves and geothermal heat, as well as carbon-neutral technologies such as biomass.” Neither fossil fuels nor nuclear fuels meet this definition of renewable energy. Solar and wind energy do meet it. Even so, we recognize that meeting this definition of “renewable” is necessary but not sufficient for a sound energy system. For instance, the production and use of biomass and fuels based on it may or may not be sustainable and in some circumstances can contribute significantly to pollution..

preserving natural resources, making our infrastructure more resilient, and making Maryland's energy system more equitable and democratic.

But as with any economic transition, there could be negative social and economic impacts, amidst the positive outcomes, if we do not prepare to address them proactively. For instance, the transition to clean and renewable energy sources necessarily entails the closure of existing fossil fuel plants; the transition to a GOTF must also plan for the contingency of nuclear plant closures, which have been occurring with increasing frequency.

The GOTF proceeding must include policies to proactively protect workers and communities from the impacts of closure by helping diversify their economies in advance. This means job creation in renewable energy, efficiency and related manufacturing and construction in the communities we know will be impacted, such as those with coal mines and coal-fired power plants, but are not yet affected.

A just transition also requires that the remaining impacts of closures when they do occur be mitigated. The means to keep schools, fire departments, police departments, and other public services running must be in place in well in advance of closures. We know where the major infrastructure of the current system that is contributing to climate change is located. The involvement of the affected communities and workers in planning the transition will be essential to a socially just result.

The programs and services that communities and workers need must also be funded. In other words, the transition to a GOTF must include a plan for affordably and equitably financing community and worker protection. The goal must be to achieve positive outcomes: to proactively create good jobs and infrastructure in the potentially affected communities so as to prevent serious dislocation when polluting facilities are closed and to mitigate such dislocation as does occur.

4. Responsive: Enhances reliability and supports the broader transition to an emissions-free energy system

The GOTF must also be able to support the electrification of sectors that now use fossil fuels directly in order to support the transition to an overall emissions-free energy system. The most important end uses of fossil fuels in Maryland are the use of fossil fuels for (i) road transportation (cars, trucks, buses, etc.) and non-road transportation (rail, tractors, lawn mowers, etc.) and (ii) space and water heating in buildings and to a lesser extent cooking.

Most of these uses of fossil fuels can be electrified. There are a great many advantages of doing so. First, electrification can lay the foundation for these applications becoming emissions-free, as the electricity sector is transformed to rely on renewable energy. In other words, electrification makes energy use “renewable-grid ready.” In addition, electrification can present new opportunities, like storage of electricity in vehicular batteries for later use at times of peak electricity demand.

Such changes will place new demands on the grid. Times of peak stress on the grid will no longer be dependent mainly on the weather: they will depend on commuting patterns as well. Electrification of heating to efficient heat pumps and away from natural gas and oil may mean peaks in the winter time, rather than in the summer as is typical today (thought here are utilities today with winter peaks). When combined with wind and solar being the mainstays of supply, peak management will become much a more dynamic function. The institutional, technical, economic and regulatory structure of the GOTF must be flexible enough to accommodate these changes and, indeed, to benefit from them.

A GOTF will need to have the capability to coordinate and integrate information from millions of consumers and devices, as well as to aggregate distributed generation, storage, and demand response. It must coordinate behind-the-meter resources with the bulk power grid. In other words the GOTF must be an intelligent grid that consists not only of wires and components that transmit and distribute electrical energy, but also a communication system that can manage it. To benefit, Marylanders will need access only to modern, energy-efficient, smart appliances and heating/cooling systems; homes, businesses, and schools will need smart devices for controlling them.

These requirements taken together mean that there must be a communication system integrated into the grid. Consumers and small producers and other participants in the energy system must have tools like broadband access and smart devices to enable them to manage their own energy. That system will allow utilities and grid operators to efficiently integrate variable and flexible resources and to optimize their operation. It will allow consumers and prosumers to optimize convenience and cost of the their use of energy services according to their requirements.

5. Equitable: Ensures low-income households have equal access to distributed energy services, ownership, and resources to optimize their usage and costs.

Low-income households and small businesses must be able to participate fully in the grid of the future. They represent a large segment of total energy demand that must be addressed if Maryland is to meet its energy and climate goals. At the same time, reducing inequities in the energy system will enhance the grid of the future, making it more efficient, cost-effective, and resilient.

Equity requires that the communications tools, broadband access, real-time information, smart appliances, and smart control devices needed to manage consumption and production at the household level be available to low-income households as well. It also means that low-income households be provided the same choices as others in terms of access to solar energy and other distributed resources, like demand response. A failure on this front will increase inequities, put low-income households at even greater risk, and imperil climate and energy system goals.

6. Resilient: Designed to ensure essential services are maintained and recovery from outages is rapid.

Recent extreme weather events in the eastern part of the United States--notably the June 2012 derecho and Hurricane Sandy later that same year--have underlined the need for greater grid resilience. This means that failure of the grid should not lead to total or near total societal collapse--people stuck in elevators in the dark, in apartment buildings without food, gasoline stations without fuel supply, non-functioning wastewater systems, and nights without any public lighting or security. Maintaining essential services for the community and rapid recovery of all services are essentials of a resilient grid.

Some resilience for some essential services is maintained today by emergency generators in hospitals and other facilities, but the aftermath of Hurricane Sandy showed that severe weather events require a broadening of the notion of essential services in the twenty-first century context in which electricity runs essentially everything. The prolonged loss of power also caused significant economic, health, and social distress and dislocation.

Microgrids are an essential part of the answer. Unlike emergency generators, which are switched on only in case of grid failure (or for testing), microgrids are local grids that operate and exchange power with the larger grid in normal times. When there is an outage, the microgrid automatically disconnects itself from the grid (a process called "islanding") and continues to provide power for essential services. One of the most dramatic examples of the utility of microgrids and the resilience they can provide was the Fukushi-Tohoku microgrid located in the Sendai region of Japan that was devastated by a huge tsunami on March 11, 2011. Power systems were wiped out. But there was one point of light: the pilot microgrid at the Tohoku Fukushi University that not only provided essential services to the campus, almost continuously.[2]

[2] Hirose, Reilly, and Irie, The NEDO Microgrid Case Study, 2012. Note that the year in the chronology should be 2011, not 2012.

The main fuel source for the microgrid power supply was natural gas, as is common for such systems. But there was also a solar PV system and a battery. The natural gas supply was wiped out along with the grid. It was the solar system and the battery that kept essential services going till the grid was restored. It took a year to restore natural gas supply.

As we move to an CO2 emissions-free world, it will be essential to ensure that microgrids operate on renewable sources--combinations of solar PV, batteries, and fuel cells or engines that operate on renewable hydrogen, for instance. GOTF regulations and public policy should encourage larger renewable energy and local storage components in microgrids, especially as these elements have broader social and technical utility. This approach will also help minimize or eliminate stranded costs that might be associated with microgrids that rely on fossil fuels. At the least, dual-fuel capability (natural gas/hydrogen for instance) should be considered for microgrid design as we transition to the GOTF.

7. Robust: Resistant to failure and failures are small and do not cascade when they occur.

While the concept of resilience has achieved broad acceptance in recent years, the term “robust” has yet to achieve currency in the GOTF context. We propose that GOTF should be “robust” in the following meanings:

- Low probability of failure in case of extreme events.
- Failure confined to as local an area as possible, with such areas being islandable to prevent propagation of failure.
- Economically robust in the sense of low vulnerability to external economic disruptions. Zero fuel cost systems that require little maintenance, such as solar PV systems and in large measure, wind farms, are examples.

Some of the principles that characterize a “robust” grid, such as isolating areas of grid outage, are already being implemented under the rubric of improved reliability. Nonetheless, we believe that the term “robust” has broader implications that are worthy of consideration in the design of the GOTF.

8. Democratic: The distributed energy grid should be decentralized, inclusive, transparent, and secure

The GOTF should make it simple and easy for everyone to participate in, and reap the benefits of, optimizing their energy decisions. The choice to produce energy should be open to all on an equitable basis, so consumers are empowered to meet their own needs. Transparency will be essential to democratization and to individual, household, and business choices about patterns of energy use and production. A communication system to make the grid transparent to consumers and prosumers will be needed for all to make informed choices. Variable energy sources -- notably solar and wind, demand response, and storage -- will make it likely that prices of energy will have to vary. Electrification of transportation will reinforce the need for price adaptability.

Maryland's technical potential for solar is high enough that the majority of households and businesses could own their electricity supply, provided that the grid were open enough to accommodate a variety of solar systems, from small rooftop systems to megawatt-scale solar farms in urban, suburban and rural areas. This will democratize the grid.

The reduction in the cost of decentralized solar generation and new financing models for solar have created the prospect that electricity consumers at all levels, from a single household to large commercial and industrial customers, can also become electricity producers. The possibility that small scale production that is also emissions-free and economical is a new and dramatic development in the electricity sector, making it possible to decentralize energy production by locating generation at the point, or very close to, where it is used, improving the efficiency and resilience of the grid.

Most of all it opens up choices for consumers as never before. Many consumers can put solar on rooftops and become consumer producers, now increasingly called "prosumers." In many states, though not yet in Maryland, consumers can also own a part of a community solar energy system that is not on their property. Maryland legislation has authorized pilot community solar projects that could lead up to broader community solar legislation. Maryland also allows farmers, non-profits, and governmental entities to aggregate electricity used at various points for the purpose of solar net metering, even though not all of them are actually connected to the solar system.This element of choice is essential for energy democracy, because it opens up the choice of becoming a producer to renters, small businesses, and many others who do not possess properties that are suitable for solar installations.

Information will be the lifeblood of the intelligent, robust, resilient, responsive grid-of-the-future, both in terms of its day-to-day operations and the real-time management of supply and demand, as well as the maintenance and development of the system as technology and energy usage evolve. The need for transparency, while maintaining security and privacy will be increased as the grid is democratized with large numbers of consumers joining the ranks of producers. Sufficiently detailed information must be available to consumers, prosumers, energy services providers, and utilities to enable them to optimize their energy use decisions and planning. The GOTF must include strong privacy and security protections to ensure consumers' personal information and rights are protected, companies' proprietary information is not vulnerable to theft or espionage, and the energy system itself is not vulnerable to sabotage or terrorism. Successful implementation of the GOTF will require a high level of consumer confidence that private information is protected.

Specific Proposals on Certain Points

Community and Worker Protection:

- Up to five years of replacement wages as a bridge to re-employment or early retirement.
- Educational, training and career development.
- Job placement services, including a direct path from training to employment.
- Healthcare and social services.
- Local property tax assistance.
- Economic development resources and planning.

Specifics on equity in the GOTF context:

- Ensuring affordable broadband and smart device access.
- Promulgating rules that require landlords to upgrade their properties with smart appliances regularly and keep their properties up to code.
- Providing access to real-time energy price information in low-income households, whether they are owned or rented properties.
- Providing training and education to enable efficient use of the tools available in the GOTF and to enable low-income families to avail themselves of the broader benefits of broadband access.
- Ensuring that bills are affordable for all, including low-income households,
- Ensuring universal solar access to low-income households in ways that would save them and the ratepayers money.
- Ensuring grid neutrality and that grid-neutrality include equity principles in regard to decentralized energy production and rate structure.

Renewable Energy/Resource Potential

Solar and wind (both onshore and offshore) energy are Maryland's main renewable resources. They have many excellent attributes, from requiring no fuel or water for their operation to being emissions-free in their operation; they are also among the most economical energy sources today. Of these, solar can be a distributed resource. The biggest difference from today's grid is that the GOTF will have to operate reliably with these variable sources at the center of energy supply. While storage and flexible generation sources, like fuel cells running on hydrogen, could in theory, provide the needed reliability, it is very likely that extensive demand response will be needed to keep the system economical and to provide consumers and prosumers with the tools to manage their bills.

Value of Solar

It is important to note here the many points of view on the value of solar energy.[3] It seems clear to us that that value is in large measure contextual. For instance, at low-levels of rooftop solar penetration in any neighborhood, local solar generation significantly reduces transmission and distribution losses. These can be as high as 15 percent on sunny, hot summer days when electricity demand is high. Solar energy eliminates fuel price risk as well as CO2 and other emissions and pollution. At high levels of penetration, solar energy can make a material difference in greatly reducing the water requirements of the electricity system even as water supply becomes more critical for a variety of reasons. At the same time, high levels of solar and other variable energy sources, notably wind, will require new elements in the grid, like storage at various levels, which introduce added cost. The value of solar to the grid and of the grid to solar is therefore not just a one-to-one question of how an individual producer relates to the grid but how the grid is to maintained and paid for so that it is reliable and resilient for everyone at all levels of penetration of variable energy sources.

Grid neutrality with equity

Ensuring that the grid is open to all consumers and producers on an equitable basis must be an essential component of the rules of the GOTF. At the same time, the grid does effectively serve as the backup for grid-connected decentralized systems, ensuring reliable supply for solar producers when local generation is insufficient to meet local demand and providing a market for surplus electricity when local generation exceeds local demand. It also serves other functions such as maintaining the quality of the electricity supply (in terms of voltage and frequency stability). The economic and regulatory structure will therefore need to serve variety of functions.

Utilities, the Public Service Commission, and the grid operator (which in the case of Maryland is PJM) must ensure reliability in this new and more challenging context. In the past there were a few hundred or at most a few thousand generators of consequence; in the future there will be millions, many of which will be susceptible to sudden swings in production (both increases and decreases).

A group of authors, including the former Chairman of the Federal Energy Regulatory Commission, Jon Wellinghoff, has set forth a set of principles for the grid of the future that are

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[3] The Maine Public Utilities Commission has published a very useful study of the value of solar that should be an essential part of the debate on the topic in Maryland.

reasonable and broad.[4] We believe they should be an essential part of the principles that should undergird the regulatory and market structure of the grid of the future. They call them "grid neutrality" principles; we quote them below:

- **Empower the consumer while maintaining universal access to safe, reliable electricity at reasonable cost**: Maximize consumers' ability to achieve their individual energy needs and the needs of the grid without compromising the universal right of all consumers to access a safe, reliable energy service at reasonable cost. We call this "*The Consumer Empowerment Principle*."
- **Demarcate the boundary between public and private interests; protect the "commons"**: Establish clear operational and jurisdictional boundaries for public and private interests. We call this "*The Commons Principle*."
- **Align risks and rewards across the industry:** Allocate financial risks to stakeholders who are most willing and able to assume them. Safeguard the public interest by containing the risks undertaken by private parties to those participants. We call this "*The Risk/Reward Principle*."
- **Create a transparent, level playing field**: Promote and protect open standards, data access and transparency to encourage sustainable innovation on the grid. Prevent any single party--public or private--from abusing its influence. We call this "*The Transparency Principle*."
- **Foster open access to the grid to parties who meet system-wide standards**: Allow all parties who meet system-wide standards the opportunity to add value to the grid. Apply all standards evenly and prevent any non-merit-based discrimination. We call this "*The Open Access Principle*."

"Open access" does imply universal access; however, in light of the centrality of equity considerations, an explicit enunciation in this regard is needed. Thus we would add a clarification to the above principles:

- Foster open access that is not discriminatory to small-scale producers and consumers, including low-income households and small businesses who do not have suitable rooftops for solar installations.

We would also add two principles that are essential to the GOTF:

- Establish resilience at reasonable cost, with a stress on renewable microgrids.
- Ensure compatibility with an emissions-free (or nearly so) electricity system in the long term (2040-2050).

Water-Efficient: Conserves and restores water resources.

[4] Hu et al 2015. "Grid Neutrality" in Public Utilities Fortnightly

The present centralized grid is dominated by thermal power plants, where a fuel is used to produce steam, which in turn drives a turbine-generator set to produce electricity. These systems typically discharge two-thirds of the energy in the fuel as waste heat to nearby water bodies--rivers, lakes, and the Chesapeake Bay. Almost three-fourths of the water consumption in the Susquehanna River basin is used for electricity generation in this way. In contrast, only 7 percent of the basin's water is used for public water supply.

In addition, about 30 percent of Maryland's electricity generation is from the Calvert Cliffs nuclear power plant, which uses Bay water for cooling and discharges the waste heat into the Bay. Based on the reactors' size and similarity to those in use at other nuclear power plants, Calvert Cliffs consumes on the order of 2 billion gallons of water per day, which also entails large impacts on aquatic life and thermal pollution of Chesapeake Bay.

This is a vulnerable system in various ways. While rainfall is usually abundant in eastern part of the United States, disruption of electric power supply by severe droughts is not out of the question. We had a glimpse of potential future problem in 2003 when a drought in the southeast forced generation curtailments and revived water disputes. Moreover, the Chesapeake Bay needs a minimum amount of fresh water to maintain its health.

Greatly reducing the use of water for electricity would increase the robustness and resilience of Maryland's electricity system, infrastructure, and economy. The fact that solar and wind energy system use essentially no water may well become a much more important value as disruptions due to climate change become more serious.

The GOTF might include goals for the reduction of water use by the electricity system in the context of other needs, such as the health of the Chesapeake Bay, the reliability of water supply for other uses, and the climate change context that includes sea-level rise and its effects of the Bay.