Comments to DEP on Reducing GHGs in New Jersey, March 10, 2020

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New Jersey Conservation Foundation appreciates the DEP's outreach to stakeholders on this issue, and offers the following initial comments, which specifically address reducing emissions from EGUs. Achieving real and deep emissions reductions, at the state, regional, national and international levels, are critically important to the future of New Jersey and its citizens, as well as to the rest of the world. Further, our reading of the Global Warming Response Act is that it requires such a nested state, regional, national and international effort, rather than a simple focus on just reducing GHG emissions within New Jersey's borders. This is particularly clear it the GWRA's requirement for the State to pursue

> … specific actions that can be taken to attack the problem of global warming through reductions of greenhouse gas emissions in the State and participation in regional and interstate initiatives to reduce these emissions regionally, nationally and internationally. [1]

We limit our comments at this time to the issues DEP raises regarding short and long-term emission reductions from EGUs. Our comments are in three sections: Short-term reductions in GHGs from EGUs, Preventing Leakage, and Longer Term GHG reductions from EGUs.

Section 1. Short-term reductions of GHGs from EGUs.

DEP's presentation at the workshop identified two basic physical modes of short-term GHG emission reductions at EGUs, namely fuel switching and increased efficiency of conversion of fuel to power (i.e., a lower heat rate). It also identified an emission per MWH performance standard for power plants and a mass-based allowance program as two potential policy drivers to lead to such reductions, as well as to deeper reductions that could result from plant closure if either of these policies result in continued operation becoming infeasible.

DEP invited comments on these approaches based on factors such as the timeframe and technology, cost, broader health impacts, local health and other community impacts, infrastructure and "utility availability." NJCF interprets this last factor as any reliability considerations due to the potential unavailability of a power plant as a result of these regulations. We offer the following comments in light of these factors.

We also address two additional criteria or factors that are critical to the development of any regulation to reduce GHGs from EGUs. The first of these is leakage, or the regulation causing unintended increases in GHG and other emissions from EGUs that are not subject to the regulation. Given the abundance of coal fired EGUs with higher emission intensity than New Jersey's relatively lower emitting gas plants, leakage due to regulating New Jersey's gas-fired power plants can be expected to lead to an increase in total GHG emissions to the atmosphere. A second, related criterion is that any regulation of EGUs should be consistent with the Energy Master Plan (EMP) and the integrated energy plan (IEP) it is based on. This is especially important since the IEP is designed to identify affordable and reliable combinations of technologies that will work well together to achieve full decarbonization of the power sector in New Jersey (and hence of its EGUs) by 2050.

[1] Global Warming Response Act, Section 2 of P.L.2007, c.112 (C.26:2C-38)

A. The factors of technologies and timeframe, reliability and cost.

i. Performance standards for existing power plants. DEP's proposed concept of performance standards for EGUs is a maximum level of GHG emissions per MWH for each power plant or type of power plant. As an initial matter, we recommend that, under a performance standard approach, different performance standards be used for combustion turbine (CT) and combined cycle gas turbine (CCGT) technologies, as discussed further below.

Such a performance standard's impact will depend on whether specific EGUs can economically achieve the standard, or instead will be forced by it to shut down. Potential economically achievable performance standards are those that can be achieved by relatively low-cost increases in plant efficiency (heat-rate improvements) or by switching to a readily available lower carbon fuel that will work in the EGU with low cost modifications. Performance standards that are set so low that they cannot be achieved through such relatively low-cost methods would result in the EGUs spending more money to make the modifications than they could earn back in power market sales, and will thus lead to the retirement of the affected EGUs instead. However, performance standards that are low enough to lead to the retirement of the heaviest emitters of a particular type of power plants but high enough to be met by new, more efficient and cleaner versions of the same type of power plant could lead to new investment in any such resources actually needed for reliability, along with an overall reduction in GHG and other emissions.

a. Performance standards for combustion turbines (CTs). Based on the information in DEP's NJPACT presentation of February 5, 2020, New Jersey's combustion turbine EGUs range from highly inefficient units that require over 25 MMBTU of fuel to produce one MWH of electricity and emit over 1.5 tons of CO2 per MWH, to the relatively efficient Bayonne plant that require 10.3 MMBTU of fuel to produce one MWH of electricity and emit approximately 0.7 tons of CO2 per MWH. These fuel and emission rates are comparable to those of the most efficient new CT and reciprocating engine technologies currently available.

Based on the per MWH fuel use and CO2 data in the NJPACT presentation, this means a performance standard for CTs of 0.6 tons (1200 lbs.) per MWH of CO2 could be met by the most efficient of New Jersey's combustion turbines, but could require either the retirement of a number of the less efficient peaking EGUs in New Jersey, or their replacement with much more efficient new technologies.[2]

There are several factors, however, that argue against a such a restrictive performance standard for CTs. First, CTs generally are used to provide very limited amounts of generation only during periods of extremely high demand or system emergencies, when their availability and output is critically important for reliability. A performance standard that such CTs could not feasibly comply with would this result in very small GHG emission reductions, at the cost of dramatically increased reliability risks.[3] In addition, the retirement of CTs, without the ability to replace them, would increase the risk of very high power

[2] The range of the CO2 per MMBTU data in the NJPACT presentation shows that many of the CTs, and potentially some of the CCGTs in the state, use varying amounts of both natural gas and liquid fuels, which have higher CO2 / MMBTU contents. The occasional use of liquid fuels can be needed to ensure reliability and affordable energy during periods when gas supplies are limited due to high heating demand. The DEP should carefully consider the benefits of such dual fuel capability in developing any performance standards for EGUs.

[3] A performance standard would also not be an effective way to guard against CTs being used for extended periods of time, since the standard is applied to the emissions per MWH, not the total amount of emissions per year.

prices during periods of high demand and system emergency, without achieving material GHG reductions. These reliability and high price impacts of too aggressive a performance standard for CTs will be especially likely if transmission congestion during periods of high demand and system emergencies prevents the delivery of peaking power from CTs or similar resources located outside of the state. Local peaking resources may be necessary to provide peaking and system emergency, since these needs typically occur when transmission is also congested.

This means aggressive performance standards that lead to the retirement of CTs may not create the regional leakage problems discussed below, but by the same token, could create reliability and affordability problems. In addition, these problems could lead to the development of more relatively inefficient, small fossil resources, such as diesel-fired reciprocating engines, that could be below the size threshold of the performance standards. This could result in minimal reductions in GHGs, and potentially an increase in other emissions with negative local health impacts. All these concerns argue for a moderate, CT-specific performance standard as the best way to reduce emissions locally without creating leakage that would offset and override those reductions in the overall region.

b. Performance standards for combined cycle gas turbine (CCGT) EGUs. The information on MMBTU and CO2 per MWH in the February 25 presentation indicates that New Jersey's CCGT plants range in efficiency from using 10.3 MMBTU and emitting 0.6 tons of CO2 per MWH to using 5.9 MMBTU and emitting 0.35 tons of CO2 per MWH. This wide range suggests that the imposition of a performance standard near the top of this range would impact few of the state's combined cycle EGUs, while a performance standard near the bottom of the range could impair all but the few most efficient ones. The reliability impact of closing a large amount of New Jersey's combined cycle plants would need to be explored carefully before proposing such a performance standard.

However, even a moderately aggressive performance standard for combined cycle units would result in shifting their generation to other parts of the regional grid, which is capable of providing a significantly greater share of New Jersey's typical power consumption than it currently does. The ability to easily shift generation to out of state resources means reliability is not likely to be threatened by closing even a significant number of in-state CCGTs. But without additional policies to effectively mitigate this "leakage," as discussed below, such a performance standard would tend to increase overall power sector GHG emissions, rather than decreasing them as is required by the mandates of climate science, as well as being called for by the GWRA, Executive Order 28 and Executive Order 100.

c. Performance standards for coal plants. Unlike natural gas-fired power plants, coal plants can technically be repowered to burn natural gas in their existing boilers, which will reduce their emission rate in rough proportion to the difference in carbon content between gas and coal. However, such conversions still may be uneconomic, and thus a performance standard based on fuel-switching from coal to gas could well result in coal plant closure. As with CCGTs, there would be no reliability impact from closing New Jersey's two remaining coal plants. Further, given the high GHG emissions per MWH of these plants, even replacing their output with power from elsewhere in the region would result in an overall reduction in GHGs, rather than an increase as would result from replacing lower-emitting combined cycle plants with a regional mix of coal and gas generation.

d. Performance standard considerations based on New Jersey's Integrated Energy Plan (IEP) and EMP. A critical issue relative to either performance standards or a mass-based allowance program for regulating EGU GHGs is the finding in the IEP that combustion turbine technology, in both stand-alone combustion turbines and in combined cycles, is likely to be an essential component of any affordable pathway to deep decarbonization by 2050. In the IEP analysis, these technologies are assumed to use a very low or zero carbon gaseous fuel (e.g., bio-fuel or a clean electricity-based fuel such as hydrogen) and are by far the lowest cost approach to matching demand during longer periods of low sunshine and wind availability. In fact, the IEP indicates that ***more*** gas-fired EGU facilities will be needed during the 2030s and beyond than are needed today. This substantial gas capacity will be needed to complement high levels of renewable resources during longer periods of low sunshine and wind, and under the IEP assumptions, will reduce its own emissions to zero by using a clean, zero-carbon biogas or hydrogen derived from clean electricity.

Consistent with the IEP analysis, any approach to GHG regulation at EGUs should be designed to keep the more efficient CTs and all or almost all of existing CCGTs in commercial operation during the time it takes to develop widely available zero or ultra-low carbon gaseous fuels they can use. Moderate separate performance standards for CTs and CCGTs are a good candidate for such a regulatory goal. Such performance standards could help promote the replacement of older, less efficient turbine resources with new combustion-turbine based technology plants that will be needed for this purpose, while also supporting the retention of today's more efficient CTs and CCGTs.

These considerations suggest that, if NJDEP were to proceed with a performance standard approach for EGUs, it would be desirable to:

- Set an initial performance standard for CTs that only excludes the least efficient existing EGUs from compliance;
- Set an initial performance standard for CCGTs that all but the least efficient existing CCGTs can comply with;
- Be prepared to decrease these performance standards over time to keep apace of the emission reductions made possible by the development and commercial availability of low and zero carbon gaseous fuels;
- Ensure that appropriate and highly effective means to prevent leakage are in place prior to setting a performance standard at a level that would otherwise result in significant leakage; and
- Set a performance standard for coal that requires either switching to natural gas or closing New Jersey's remaining coal plants.

ii. A **mass-based allowance program.** Any more stringent mass-based allowance system in New Jersey would have to operate on top of, and in addition to, RGGI. Like RGGI, any such mass-based approach would tend to reduce local emissions by increasing the marginal operating costs of power plants by the per-MWH cost of the allowances needed to comply with the program.

a. Mass-based approaches induce leakage and can thus increase rather than decrease GHG emissions. This higher cost would tend to reduce the output of the regulated power plants, but would at the same time make power plants in other parts of the region more competitive in PJM's regional electricity market, causing their output to increase to replace the reduced output in New Jersey. Further, the regional power mix has considerably more coal in it, and in locations with very inexpensive natural gas, this more expensive coal shifts coal plants from around-the-clock operation at full output to providing flexible ramping up and down of output to provide hourly and daily balancing services. As a result, the shift of producing electricity and flexible balancing services from relatively efficient and clean New

Jersey natural gas plants to less efficient and much more carbon-intensive regional coal plants would cause a substantial overall increase in GHG emissions.

This net increase in emissions is a classic example of *economic leakage*, which can be a problem for all mass-based emission reduction systems. In the electric sector, economic leakage occurs when one part of an integrated electrical region imposes a cap or a price on carbon, which increases the marginal cost of generation at regulated plants within the region relative to the marginal cost of generation of plants elsewhere in the region. As a result of this relative change in costs, the unregulated regional plants are dispatched before and instead of the regulated local plants to meet the same overall regional energy consumption needs.

Because of this leakage problem, virtually any mass-based allowance program for New Jersey's more efficient gas-fired power plants would, without additional effective measures to avoid or mitigate leakage, almost certainly lead to an overall *increase* in GHG emissions, due to reductions in power generated at New Jersey's cleaner EGUs being replaced by power generated by higher emitting coal plants and less-efficient gas plants in other parts of the region.[4] This fact alone suggests that a mass-based approach will be counterproductive in achieving GHG emission reductions, and should be avoided.

While a performance standard approach could also readily create leakage that would outweigh its in-state emissions reductions, this would only happen if the performance standard approach resulted in significantly reduced operation or closure of in-state EGUs. A modest initial performance standard approach such as that recommended above, however, would create little or no leakage, and thus would have the potential to achieve greater overall emission reductions than a mass-based approach, whose in-state emission reductions are likely to be exceeded by increased regional emissions caused by leakage due to the in-state program.

b. Mass-based approaches may not limit emissions from marginal and inframarginal resources. In power markets, the price of electricity is set by the marginal costs of the most expensive EGU needed to meet demand at each moment. This means that power prices are low at lower levels of demand, when larger power plants using cheaper fuels more efficiently are in use, and higher at higher levels of demand, when the additional output of smaller but more flexible power plants using more expensive fuels and less costly but less efficient technologies is needed to meet higher levels of consumption, on top of the continued output of the plants that are already running to meet lower levels of demand.

One implication of this is that, under a mass-based allowance approach to GHG regulation, whatever EGU is setting the electricity price gets all of their compliance costs back from power sales. This happens because the cost of the allowances needed to comply with the mass-based approach are part of the marginal cost of each EGU, and the EGU bids those marginal costs into the market and is paid them whenever it is asked to run. This means that, under a mass-based approach, marginal EGUs make just as much money as they would without any regulation. And, if at even higher levels of demand, the next EGU dispatched will typically be less efficient (i.e., burn more gas and release more CO2 per MWH),

[4] See PJM's January 14, 2020 analysis of leakage in response to RGGI's mass-based allowance system, available at: https://pjm.com/-/media/committees-groups/task-forces/cpstf/2020/20200114/20200114-item-03-pjm-study-of-carbon-pricing-and-potential-leakage-mitigation-mechanisms.ashx Last accessed February 18, 2020.

and thus will set an even higher price that will actually earn gas-fired generators that are already running more than their own compliance costs.

Table 1 below shows the marginal fuel and mass-based allowance system compliance costs, based on the MBTU and CO2 per MWH characteristics of several New Jersey EGUs, as provided in the February 25th NJPACT presentation. For simplicity, we assume natural gas costs $3.50 per MMBTU and total allowance costs per ton of $16.

			TABLE 1				
	CO2/BTU	CO2/MWH	MMBTU/MWH	CO2 T / MWH	Fuel cost / MWH	Compliance cost / MWH	Marginal cost / MWH
Carlls Corner	125	3350	26.8	1.68	93.80	26.80	120.60
Mickleton	117	3100	26.5	1.55	92.74	24.80	117.54
West Station	161	2,500	15.5	1.25	54.35	20.00	74.35
Sayreville	149	2,400	16.1	1.20	56.38	19.20	75.58
Sherman Ave	117	1500	12.8	0.75	44.87	12.00	56.87
Essex	117	1300	11.1	0.65	38.89	10.40	49.29
Bayonne	117	1200	10.3	0.60	35.90	9.60	45.50
Lakewood	117	900	7.7	0.45	26.92	7.20	34.12
Woodbridge	117	750	6.4	0.38	22.44	6.00	28.44
Sewaren	117	690	5.9	0.35	20.64	5.52	26.16
input costs					3.50	16.00	

The column labeled “Fuel cost / MWH” is a reasonable approximation of the marginal cost-based bids these plants would submit into PJM’s electricity market without a mass-based GHG regulation regime. Under such a regime with allowance costs of $16 per ton of CO2 emitted, each plant would incur the additional out-of-pocket costs shown in the column labeled “Compliance cost / MWH”, and would bid the sum of these marginal costs into the PJM market, as shown in the column labeled “Marginal cost/ MWH”. In other words, the mass-based allowance program increases each EGU’s bids from the amount in the fuel cost column to the amount in the marginal cost column by the amount in the compliance cost column.

Accordingly, when a plant like the Essex plant, under the assumptions in Table 1, is the highest marginal cost plant needed to meet load, without a carbon price it would bid $38.89 per MWH and would set price at that level. The first thing to note is that the carbon price doesn’t necessarily reduce its production, if it is still needed to meet load. Instead, it just runs and sets market prices at a somewhat higher level. That is, when the Essex or a similar plant is needed to meet load, it will be running and setting price at $38.89, and will get back all of its marginal costs.

The second thing to note is that, when the Essex plant is called to meet load, all the plants with lower marginal costs are already running. The Woodbridge plant, for example, would already be running, based on its lower bid of $22.34. This means that the Woodbridge plant is earning a margin, above and beyond its fuel costs, of $38.89 - $22.34 = $16.45 on each MWH it generates while demand remains at this level. This margin helps the Woodbridge plant pay for non-fuel costs, such as labor, property taxes, depreciation, taxes, and capital.

What happens if there is suddenly a carbon price of $16 per ton? The Woodbridge plant’s bid goes up by $5.52 to $26.16. But since the Essex plant burns more gas and emits more CO2 per MWH, its bid goes up by $10.40 to $49.29. Again, if the Essex plant is the plant with the highest marginal cost needed to meet load, its bid will be selected, it will run (in addition to all the plants with lower marginal costs) and it will set the market price at $49.29 and get all its marginal costs back. But now the Woodbridge plant is earning a margin of $49.29 - $28.44 on every MWH it generates while load is at this level.

The price on carbon has left the Essex plant indifferent in terms of how much it receives when it sets price – it still just gets its marginal cost back. However, the Woodbridge plant affirmatively benefits in terms of its margin per MWH at such load levels, which, thanks to the price on carbon, has increased from $16.45 to $20.85. As can be seen from the table, all the EGUs with marginal costs below those of Essex will also get higher margins per MWH, thanks to the price on carbon. And, at even higher levels of demand, plants with even higher fuel and compliance costs will set price, and Essex, like all the other plants with marginal costs lower than the price-setting EGU, will make higher margins per MWH with a carbon price than they would without.

For this reason, a mass-based approach is often favored by gas-fired generation owners, since it is highly likely to make them more money, at least before the carbon budget becomes small enough to exclude some gas generation from operating.

This potential "carbon uplift" in earnings for gas-fired generators under a mass-based approach is closely connected to the leakage problem such mass-based approaches create. The same higher marginal costs that can produce the uplift also tend to take it away, by substituting a cheaper bid from elsewhere in PJM for the bid of the New Jersey resource that is now higher due to the carbon allowance. Thus, instead of reducing GHGs and increasing earnings for local gas plants, a mass-based program's economic leakage caused by a carbon price can increase GHGs and increase earnings for regional coal plants, while reducing both sales volume and margins, relative to their costs, for New Jersey's gas plants. In other words, to the extent a downside of mass-based approaches is their potential to financially reward emitting plants, an even greater downside is their ability, when used at the sub-regional level, to shift power production to elsewhere in the region and, in so doing, to both increase overall emissions and to create financial windfalls for the owners of those higher emitting, out-of-state EGUs.

c. These considerations suggest that any more aggressive mass-based approach to GHG regulation should be avoided until effective means to avoid or mitigate leakage can be identified, developed and implemented. Otherwise, any more aggressive mass-based approach will almost certainly violate the scientific, moral and legal imperatives facing New Jersey to reduce GHG emissions in the state, regionally while contributing to national and international reductions.

B. The factors of health and community impacts. The health impacts of reducing GHG emissions from EGUs will, in the short run, consist entirely of co-benefits of reducing emissions of particulates, NOx, and other EGU emissions with direct impacts on human health. Some of these emissions may best be controlled by approaches other than either GHG performance standards or mass-based GHG regulations. However, of these two approaches, performance standards may be more effective at reducing the exposure of local populations to pollutants that harm their health. In evaluating the potential local benefits, it is important to focus on reducing the actual tons of emissions rather than simply their emission rate per MWH, since EGUs with higher emission rates (CTs) may none-the-less emit far fewer tons of pollutants over time than more efficient CCGTs, that emit fewer pollutants per MWH but emit more per year because their greater efficiency results in a lower cost and much greater utilization.

Evaluation of local health benefits from reduced power plant operation should also consider the potential for these benefits to be eroded through leakage. For example, the co-benefit of reducing local emissions of NOx due to limiting or ceasing local EGU operation could be reduced or overwhelmed if leakage simultaneously increases the upwind emissions of particulate emissions from coal combustion, along with more NOx from less efficient regional gas-fired plants. An alternative that may produce more local health and community benefits may be to impose performance standards only on the least efficient CTs and CCGTs, while simultaneously developing ways to reduce the overall energy production and emissions of the remaining, more efficient CTs and CCGTs. These reductions in energy production and emissions could be achieved through many of the same targeted approaches to clean energy resource deployment that have the potential to avoid or significantly mitigate leakage, as discussed next.

Section 2. Avoiding or mitigating leakage. Because leakage so fundamentally interferes with effective GHG reductions through regulation at the state level, it is critical for the DEP and other state agencies to consider all potential effective ways to mitigate or avoid leakage as part of any regulatory approach to reduce GHGs rapidly.

A. Both physical and economic leakage must be addressed. As an initial matter, leakage can be caused by both economic factors, such as a price on carbon, and by physical changes in the grid, such as the retirement or addition of various types of energy resources. Both types could result from GHG regulatory approaches as well as from other aspects of New Jersey's clean energy development policies and initiatives. Accordingly, it is important to recognize and address both types.

We have already discussed how economic leakage is caused when a compliance obligation in one part of an electrically-connected region imposes higher marginal operating costs on local EGUs than other EGUs face in other parts of the region. Physical leakage, by contrast, is caused by physical changes in the grid, such as the closure or dramatic reductions in power production by local EGUs, or increased local deployment of wind and solar energy. Such *physical* forms of leakage happen because the electric system's reliability requires constant matching of electricity generation with electricity demand, so a local reduction in generation, whether due to the permanent loss of a local generating unit or the inherent intermittency of increased renewable generation, will have to be met with an increase in some other contemporaneous generation or equivalent reduction in load. If this needed replacement resource cannot be supplied locally, it will typically be supplied by more GHG intensive resources in the region, resulting in leakage just as real, and just and dangerous to the climate, as economic leakage.

Currently, it appears likely that RGGI's mass-based allowance system and relatively low carbon prices is already creating enough leakage to interfere with achieving our collective climate goals. A more aggressive mass-based approach, without additional new means to prevent or minimize leakage, can only make the problem worse.[5] And, as discussed above, a system of performance standards would itself be limited to modest results without effective means to mitigate leakage. Accordingly, below we identify several potentially promising approaches to reduce leakage in the near term and medium term.

B. New Jersey's EMP is based on physical emission reductions. The bulk of New Jersey's leadership on GHG emission reductions has been and continues to be based on displacing GHG emissions by physically substituting clean energy systems and technologies for carbon-intensive ones. The IEP and EMP

[5] See, e.g., the PJM analysis and reports cited above at fn. 3.

reinforce and enhance this physical approach. From this perspective, physical displacement of GHG emissions by clean energy alternatives is the intended effect, and leakage is simply an unintended side effect. In fact, one key feature of the IEP modeling is its integrated, dispatch-based analysis of the electric system to find those combinations of resources that can best achieve deep emission reductions and avoid unintended leakage. This concept points to the first of our recommended strategies for avoiding and mitigating leakage:

i. Targeting physical clean energy resource deployment to preempt leakage. New Jersey's innovative approach to identifying the most efficient physical combination of clean energy resources that can rapidly reduce total GHG emissions should, in our view, also provide the overall framework for figuring out how to regulate GHGs in a manner that supports and accelerates the EMP's goals, including by preventing leakage. From this perspective, one promising candidate for preventing leakage is to identify the specific clean energy resource types and quantities that would provide the same electricity services as New Jersey EGUs, and to support their deployment so that they provide the energy production and reliability services that used to be provided by New Jersey fossil resources. Without this deployment, the missing electricity services would readily be supplied by existing more GHG-intensive regional resources.

For example, clean short-term sources of flexible storage and load control in the right combinations and amounts, may someday replicate many of the services provided by CTs. However, this will require substantially improved control and management technologies that will allow these clean, distributed resources to interact freely with the wholesale power market dispatch of EGUs. Such distributed energy management systems are not yet widely available, and market rules are still in their infancy in terms of being able to support and incorporate such resources.

But with the development and widespread deployment of such efficient control systems and market rules, these clean distributed resources would allow CTs to run less frequently and for shorter periods when they are needed. This would substantially reduce their GHGs and other emissions, while still allowing them to provide the reliability and economic benefits needed during system emergencies and high peak loads when batteries and flexible load are likely to be unavailable.[6] Such a mix of flexible clean energy resources could ensure reliability, while limiting or even preventing any leakage to fossil peaking resources in the rest of the region. Further, such a mix of clean flexible resources could be tailored to fill in any daily or hourly gaps in energy production caused by higher levels of intermittent renewables located in New Jersey, thus preventing physical leakage that could otherwise result from higher levels of renewables and lower levels of gas generation in New Jersey, even in the absence of GHG regulation and the economic leakage it could cause.

Turning to CCGTs, they provide primarily large amounts of electric energy, and more limited amounts of reliability and balancing services. Much of this energy production, and its associated emissions, could be avoided by a growing, regionally diverse mix of wind and solar, coupled with larger and complementary

[6] For batteries and flexible load to be available, there must have been enough recent energy availability for them batteries to recharge and HVAC systems to reestablish comfortable temperatures. For this reason, battery storage and flexible load will likely be unable to meet peak demand and emergency needs that occur during extended periods of cloudiness and calm winds. However, they may well be able to meet, or help meet, such needs when they occur during an extended sunny and windy period. This is one reason why the IEP finds that gas turbine technology, with new zero-carbon fuels, are likely to be essential for affordable deep decarbonization in the mid 2030's and beyond.

amounts of the same clean storage and load management technologies discussed above. As with CTs, this new suite of clean energy resources would allow significantly less gas use in energy production, while saving CCGT technology to be used primarily during prolonged low levels of wind and solar output.

Further, because this mix of local and regional renewables and clean flexible resources would provide many of the same energy services as CCGT and CT EGUs, without emitting GHGs, it would do more than simply reduce overall emissions. It would also help *prevent and preempt leakage of emissions* from New Jersey gas plants that run less, to more carbon-intensive regional generators that would otherwise fill in for New Jersey's CCGTs and CTs.

Importantly, in both the CT displacement and the CCGT displacement scenarios, the clean resources can be, and in some cases may need to be, located both inside and outside of New Jersey. The recent IEP and EMP suggest that getting an efficient blend of these regional and local clean energy resources is likely to be essential to ensuring affordability, reliability and the most rapid GHG emission reductions.

The good news here is that New Jersey's EMP is based on an analytical approach to identifying the right mix and amount of all resources, including storage and flexible load, clean fuels, existing nuclear or its potential replacements, and the gradual phase-down or phase-out of fossil fuel emissions, to achieve the state's emission reduction goals at reasonable costs. The implementation phase of the EMP, which includes the DEP's exploration of the best approach to regulate and reduce GHG emissions, is the natural place to take the next steps of identifying, with more precision and granularity, the types and amounts of flexible resources that would specifically be needed, as part of the evolving resource mix, to avoid or effectively mitigate leakage.[7]

The less good news is that the full suite of the technologies needed to avoid or mitigate leakage are unlikely to be available at sufficient scale and low enough costs to mitigate increased GHG emissions from leakage for some time -- perhaps the next five years. Not only will such mitigation require the deployment of large amounts of clean flexible resources and additional regional wind and solar, it will also require identifying, developing and deploying efficient distributed energy resource control and management systems, along with new protocols and practices to allow them to integrate with and influence the dispatch of EGUs in the regional wholesale market.

Because it will take time to carry out these important tasks, the DEP should, with the BPU and stakeholders, focus on deeper analysis, consistent with the general direction of the IEP and the EMP, on avoiding and mitigating leakage as part of the overall decarbonization effort. Options to consider for such leakage control are offered below.

ii. A broader RGGI? Leakage occurs when regional EGUs can economically substitute for regulated in-state EGUs. Due to electrical losses and congestion, such substitution is generally more likely the closer the regional resources are to New Jersey. Thus, it stands to reason that a significant amount of the leakage in response to more aggressive GHG regulation in New Jersey would come from Pennsylvania. If Pennsylvania joins RGGI, as it has been planning to, RGGI-based leakage would tend to shift further westward and would likely be less directly coupled to New Jersey emission regulations. The DEP and

[7] It is important that modeling of leakage and leakage mitigation be done using the most accurate depiction of PJM's electric system topology, dispatch and price formation processes available. Broader planning models, such as those used in the IEP, are less likely to produce the precise results needed to identify and prevent or mitigate leakage risks.

BPU should carefully analyze the implications for leakage of Pennsylvania's decision to join RGGI, both under RGGI as is and under any approach to a more aggressive GHG regulatory regime in New Jersey.

iii. Border adjustments? One potential policy to mitigate economic leakage is the concept of "border adjustments" in the regional electricity market. Border adjustments are used to some benefit in the California ISO's Energy Imbalance Market, which spans much of the region from the Rocky Mountains to the Pacific. The CAISO approach involves imputing the costs of compliance with a regional carbon price (California's AB 32 cap and trade regime, similar to the RGGI regime in the east) to any generators from the unregulated region, that submit schedules to transfer electricity from outside of California into the state. The PJM analysis of leakage referenced above is also exploring variants of this border adjustment approach in the context of RGGI and the PJM electricity market. Preliminary results suggest that it would be a relatively inefficient way to mitigate leakage, and could face significant implementation challenges. While further analysis is indicated, especially of the case where Pennsylvania does indeed join RGGI, these early results suggest that border adjustments may not offer a useful approach for avoiding or mitigating leakage.

iv. Imputing a carbon price among some or all PJM states? Another concept to explore is the possibility of PJM imputing a carbon price to the dispatch of all power plants, either across its entire footprint, or just in PJM states that have embraced GHG emission reduction goals. Such an approach may work better than border adjustments, and deserves additional analysis and stress-testing. Potential problems with this approach include leakage impacts due to non-participating states and the difficulty of achieving a consensus and gaining FERC approval for such a proposal.

v. A dynamic clean electricity standard? One of the challenges facing New Jersey is whether and how to use the basic compliance and incentive framework of the current renewable portfolio standard (RPS) to help incentivize the deployment of the various clean energy technologies envisioned in the EMP. Such an approach could, for example, consist of a clean electricity standard that would require the state's load serving entities (LSEs) to obtain clean electricity credits (CECs) equal to specific percentages of their retail sales, above and beyond the 50 percent RPS requirements in existing law.[8] Pairing such a credit system with a more aggressive GHG regulatory scheme could, in concept, incent additional clean energy resources that would preempt or displace the dispatch of the regional fossil-generators that would otherwise create leakage by replacing higher cost or physically unavailable New Jersey gas plants.

For this to work, however, the clean energy resources would have to be capable of being dispatched at the same time, and to meet the same load and reliability needs, as the fossil plants they are intended to displace and replace. This is not very likely under a program using existing types of RECs or CECs, which are awarded based on annual electricity production, rather than on the clean electricity actually be generated when needed to displace the use of GHG-emitting fossil resources. This feature of ordinary RECs and CECs could be especially problematic at higher levels of renewable energy production, when incremental wind and solar are increasingly likely to displace other wind and solar resources in the power system's dispatch, rather than displacing remaining fossil resources. To actually focus clean energy investment on displacing fossil resources and their GHG emissions, a system of dynamic clean

[8] It will be important, and we think possible, to structure any such new CES policy in a way that does not upset the cash flow, contractual or other rights and obligations of clean energy projects that rely on the REC, SREC, OREC or ZEC programs for revenues and project finance.

energy credits (DCECs) has recently been proposed that awards credits based on the marginal emissions avoided by each clean MWH generated.[9]

The potential relevance of such a dynamic credit system to leakage avoidance or mitigation may be substantial. Projects that displace the greatest amount of GHG-intensive generation would receive the most DCECs. Further, as is the case currently with RECs under New Jersey's RPS, DCECs could be awarded to clean energy resources located in New Jersey and in other parts of the region. This means that any leakage resulting from New Jersey policy would become a magnet for the specific types of clean energy resources – including storage, flexible load, and gas switching to clean fuels – that would provide the same balancing services, without emitting GHGs, and that would physically displace the fossil generation that would otherwise replace economically or physically reduced generation in New Jersey.

In addition to these automatic incentives for clean energy investors to target and eliminate leakage, a DCES could play a significant role in supporting and guiding the investments needed, both in the state and regionally, to actually achieve the deployment of clean energy resources envisioned by the EMP.

Section 3. Long-term emission reductions and summary.

Our analysis suggests that the long-term reduction of GHG emissions will be driven primarily by rapid, ongoing investment in the critical clean energy resources needed for rapid decarbonization. As indicated by the IEP and EMP, this mix will evolve over time and be located both inside New Jersey and across the region. Success will need thoughtful new policies and incentives to spur the development of an entire new energy ecosystem, not just the reduction of GHG emissions from existing resources.

Regulations supporting the achievement of those emission reductions, however, may be needed to ensure the existing resources get out of the way, where and when they are no longer needed for low cost, rapid decarbonization – and to help spur the new energy ecosystem to provide the zero carbon fuels some of them may need to fully support and enhance rapid decarbonization.

But for any such system of regulations to work, it must directly accept and win the challenge of avoiding or mitigating leakage. This challenge cannot be avoided by focusing only on emission reductions within the state, especially if the in-state reductions cause emissions to increase outside of the state. Similarly, it cannot be avoided by a choice between performance standards or mass-based allocation approaches to regulating EGUs.

Our analysis does suggest, however, that leakage could initially be minimized or avoided by starting with a moderate rate-based approach, rather than digging immediately into a more restrictive "RGGI plus" emissions budget. However, to avoid leakage and net increases in emissions, even this moderate rate-based approach should be designed to achieve the physical closure of only the heaviest emitting CTs and CCGTs, while allowing their replacement with efficient new turbine technologies, consistent with the IEP's insights into the need to preserve and expand the fleet of efficient, modern gas turbine-based

[9] This dynamic clean electricity credit concept is based on the Dynamic Clean Energy Attribute Credit proposed by Brattle in Part H. of the Appendix to their Report *How States, Cities and Customers Can Harness Competitive Markets to Meet Ambitious Carbon Goals.* of September 2019. See pp. 34-38 for the explanation of dynamic credits and their benefits. Available at https://c212.net/c/link/?t=0&l=en&o=2581945-1&h=2849883070&u=https%3A%2F%2Fbrattlefiles.blob.core.windows.net%2Ffiles%2F17063_how_states_cities_and_customers_can_harness_competitive_markets_to_meet_ambitious_carbon_goals_-_through_a_forward_market_for_clean_energy_attributes.pdf&a=white+paper . Accessed February 18, 2020.

EGUs. This approach would also provide immediate health and community benefits by also dramatically reducing health-related emissions from these older, least efficient, and heaviest emitting units, while affording more time to address the critical issue of leakage. If and when successful approaches to avoiding or mitigating leakage are developed, more aggressive regulation, consistent with the evolving IEP and EMP process, can be developed and deployed.

To achieve all these goals, we recommend the following sequential approach:

1) Develop a power sector GHG emission reduction projection consistent with the least cost IEP scenario, and base EO 100's "broad criteria to govern and reduce" GHGs on the projection.

2) Consistent with these broad GHG emission reduction criteria, develop and promulgate separate performance standards, one for CCGTs and another for simple cycle/ CT EGUs. These performance criteria should be designed to initially avoid constraining the operation or economics of the more efficient of each types of resources, consistent with the IEP findings of the need for retaining and even expanding the fleet of efficient, modern, turbine technologies, while also supporting the development and broad availability of clean fuels for them to use.

3) Develop, in partnership with the BPU, stakeholders and appropriate experts, the ability to model and project EGU dispatch and leakage using state-of-art, highly accurate models of PJM's electric topology and dispatch process. Use these tools, in concert with the BPU and stakeholders, to explore options for the targeted physical deployment of specific amounts, types and locations of clean energy resources that can specifically prevent or minimize leakage from both increased deployment of wind and solar in New Jersey and from reduced gas plant operation in the state; and to explore other potential approaches to avoiding or mitigating leakage, including those suggested in these comments, and select the most promising for development as part of the state's EMP implementation and its parallel approach to GHG regulation.

4) Through the EMP, regularly evaluate the attainment of the emission reduction schedule, including whether they are being met without leakage, and adjust the clean energy deployment goals and policies and / or the regulatory criteria and specific regulatory policies as needed to ensure the emission reductions are achieved, both in-state and regionally.

Central to these recommendations is the view that the DEP's "criteria to govern and reduce GHGs" should not be designed to be the driver of the state's emission reductions. Instead, that driver should be the evolving EMP, the incentives and policies developed pursuant to it, and the private and public investments in the key elements of a clean energy economy they spur. The DEP's "governing criteria" and any regulations they entail should serve more as guard rails along the EMP's path, in case the driver is unable on occasion to stay on the road to decarbonization and needs the protection of such guardrails to avoid going over the cliff of runaway climate change. But it is always better to plan for the driver to actually steer the car rather than to rely on colliding with the blunt instrument of regulation to do so.