Port of Savannah Shore Power Analysis

Developed for John Kaltenstein, Friends of the Earth

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Background

The Port of Savannah is ranked fourth in the country in container volume,[1] handling over 4 million TEUs in 2017.[2] Its Garden City Terminal is the nation's largest single container terminal in the U.S encompassing more than 1,200 acres,[3] attracting more weekly vessel calls than any other port on the East Coast. This volume of traffic can have a significant impact on local air quality, specifically during the extended period that a vessel is dockside unloading and loading cargo. During this time, auxiliary marine diesel engines operate in order to maintain onboard power and assist in cargo handling operations.

Shore power provides an alternative to running auxiliary engines that has the potential to reduce air pollutant emissions in a cost-effective manner. The electricity ships need to power their ancillary systems while at berth can be produced with fewer emissions using land-side electricity generation power sources (e.g., power plants) when compared with onboard diesel-powered auxiliary engines. At this time, the Port of Savannah does not have shore power at any of its terminals.

The magnitude of potential emission reductions depends on the mix of electricity generation power sources, which can vary by location. The mix of power sources in the state of Georgia (Figure 1) includes a diverse variety of cleaner energy sources which are collectively priced below marine diesel fuel, such that shore power is an economically viable option for reducing air emissions.[4]

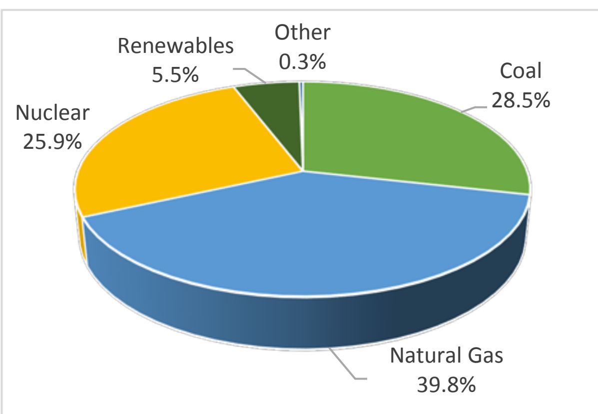

Figure 1. Mix of Energy Source for State of Georgia Electricity Grid

The U.S. EPA's Emission and Generation Resource Integrated Database (eGRID) has comprehensive data on the environmental characteristics, including air pollutant emissions, of electric power generated in the U.S. eGRID provides emission factors that account for the mix of different energy generating units (ERUs) for each state or sub-region. Table 1 below shows the 2016 eGRID emission factors for the state of Georgia in terms of g/kWh that were used to estimate the emissions contribution of shore power.[5] Note that eGRID has emission factors for NO_x, SO_2, CO_2, CH_4; supplemental emission factors were developed for $PM_{2.5}$ and VOC based on Argonne Lab's GREET model as summarized in a BOEM analysis of the impact that offshore wind power has on reducing emissions from electricity generating

[1] Savannah Economic Development Authority, 2016, http://www.seda.org/Data-Sets/Transportation-(2)/Port-of-Savannah

[2] Georgia Ports Authority, Georgia Ports Authority by the Numbers, 2018, http://gaports.com/about/gpa-by-the-numbers

[3] Georgia Ports Authority, 2018, Largest Single Container Port in North America, http://gaports.com/port-of-savannah

[4] U.S. EPA 2016 eGRID, 2018, https://www.epa.gov/sites/production/files/2018-02/egrid2016_summarytables.xlsx

[5] The 2018 eGRID figures come out in 1Q 2020 and are likely to show a reduction in emissions (i.e., accounting for a cleaner grid in GA).

units.[6] The Black Carbon emission factor was developed for the BOEM Offshore Wind Energy Facilities Emission Estimating Tool; the value in Table 1 is for the SERC South e-GRID subregion as state-specific values were not available.[7]

Table 1. Emission Factors State-Level Electrical Grid Mix

Pollutant	eGRID Emissions Rate Reflecting Energy Source Mix for the State of Georgia (g/kWh)
NO_X	0.18
SO_2	0.18
CO_2	454.4
CH_4	0.04
$PM_{2.5}$	0.08
Black Carbon	0.00215
VOC	0.01

To get a sense of the potential emission reduction for shore power, Georgia's eGRID emission factors can be compared with the EPA's diesel marine vessel emission factors which were recently updated for use in their new commercial marine vessel emissions model. As EPA's work does not include Black Carbon, the BC emission factor below was provided for this study by Dr. Bryan Comer from ICCT.[8] [9] These latest marine vessel emission factors are listed in Table 2 by vessel tier based on the year the vessel was constructed. Note that the estimate provided includes only primary PM, and it is anticipated that there could also be significant reductions of secondary nitrate and sulfate PM generations. Additionally, future studies may want to investigate the reduction of some of the precursors for sulfate formation given the use of ECA-compliant fuels as compared to onshore sources.

Table 2. Auxiliary Engine Emission Factors (assuming medium speed diesel using marine gas oil (0.1% S) [10] (g/kWh)

Build Year	Tier	NO_x	SO_2	CO_2	CH_4	$PM_{2.5}$	BC	VOC
< 2000	Tier 0	11.227	0.450	723.530	0.090	0.184	0.1	0.522
2000-2010	Tier 1	10.094	0.450	723.530	1.090	0.184	0.1	0.522
2011-2015	Tier 2	7.931	0.450	723.530	2.090	0.184	0.1	0.522
≥ 2016	Tier 3	2.060	0.450	723.530	3.090	0.184	0.1	0.522

Methodology

Friends of the Earth provided a vessel call log for Garden City Terminal which was used for this study.[11] The log provided the vessel name, IMO number, and hours at berth for each of the 1,866 containership calls in 2017.

6 BOEM Shore Power Tool – Technical Document, 2017, https://www.boem.gov/Technical-Documentation-stakeholder/

7 Chang, R., B. Do, and R. Billings. 2017. Technical Documentation for the Offshore Wind Energy Facilities Emission Estimating Tool. US Dept. of the Interior, Bureau of Ocean Energy Management, Sterling, VA. OCS Study BOEM 2017-xxx. 51 pp. https://www.boem.gov/Technical-Documentation-stakeholder/

8 Email correspondence between Richard Billings, ERG and Dr. Bryan Comer, ICCT, Dec 19, 2018.

9 Note that BC formation is dependent on many different fuel characteristics that may not contribute to total PM formation, such that there is no set ratio of BC to PM. Results would vary if other emission factors are used.

10 Newly developed emission factors from U.S. EPA 2017 National Emission Inventory, pending publication in 2019. These vary slightly from other commonly used emission factors from CARB, IMO, or previous EPA guidance.

11 The vessel call data from 2017 was given to Friends of the Earth by the Georgia Port Authority on Oct. 3, 2018, in response to a Georgia Open Records Act request.

Average time spent at berth was approximately 22 hours per call.[12] The trips were associated with 522 unique containerships, of which 73 did not have an IMO number. These were researched online to obtain IMO information. The IMO numbers were then matched to Clarkson's database of marine vessel characteristics to obtain ship-specific vessel type (i.e., confirming they are all containerships), build year, and auxiliary engine horsepower. Four of the vessels, with seven vessel calls between them, were not found in Clarkson's database; a default auxiliary engine size of 6,800 kW was used to include them in the calculations.

While 99% of the vessels matched to the Clarkson database, only 403 of the 522 containerships had power data for auxiliary engines in the Clarkson database (77%). To gap-fill the missing auxiliary engines, an EPA default value of 6,800 kWs was used.[13] Actual auxiliary engine power ratings may be larger than the EPA default; the port may want to consider collecting auxiliary engine data for visiting vessels to provide more accurate estimates of power demand and emissions.

Vessel calls were grouped by auxiliary power to remove vessel-specific data (per use agreement with Clarkson), and vessel trips and hours at berth were summed. EPA's Shore Power Emissions Calculator[14] was used to estimate emissions for both vessel-auxiliary emissions as well as shore power emissions. Anticipated reductions in emissions using shore power were calculated and are shown in Table 4 below. Financial savings of using shore power instead of burning marine diesel fuel for auxiliary engines were also calculated (Table 5).

Emission Estimation Approach

Annual dockside power demand was calculated for each vessel in the fleet using the following equation:

$$\text{PD} = AP \times LF \times T$$

Where:

PD = Hoteling power demand for each vessel visit (kWh)
AP = Auxiliary engine power (kW)
LF = Auxiliary engine hoteling load factor (17% for containerships)
T = Duration per call adjusted to account for connection and disconnection time (2 hours)

This equation assumes one hour to connect and one hour to disconnect on to the shore power system to ensure that vessel emissions are for the same period of time as the period when the vessel is connected to the shore power system. This is a conservative estimate in line with other studies. The power demand values were used to estimate baseline emissions from the auxiliary engines while dockside using the following equation:

$$\text{AE} = \sum \text{PD} \times \text{A}EF / 1{,}000{,}000$$

Where:

AE = Dockside emissions (metric tons)
PD = Hoteling Power demand (kWh)
AEF = Auxiliary engine emission factor (g/kWh)
1,000,000 = Factor to convert from grams to metric tons

Auxiliary engine emission factors are Tier-based as determined by the age of vessel. It is also assumed that the auxiliary engines are medium speed diesel using Emission Control Area compliant fuels with 0.1% sulfur content.

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[12] The original average time at berth determination was approximately 23.5 hours; however, the *MS Swan*, which appeared on GPA's containership call listing, is actually a heavy load carrier, and its 256-hour stay was removed.

[13] U.S. EPA, Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, 2009.

[14] U.S. EPA Ports Initiative, Shore Power Technology Assessment, 2017, https://www.epa.gov/ports-initiative/shore-power-technology-assessment-us-ports

The EPA's default auxiliary operating load factor for containerships is 17%[15] which is considered a low load operation (i.e., less than 20%) when marine engines are operating outside their design efficiency, generating more emissions. However, other regional studies have indicated that containerships have multiple auxiliary engines and that ship operators may turn off certain auxiliary engines to maximize load and increase efficiency while in port. Nevertheless, data are lacking to indicate the precise engine load achieved with this practice. Consistent with other studies, the calculations here continue to use the 17% load factor but do not include the standard low load adjustment. Note that the tool has built-in flexibility to change this assumption as well as to calculate emissions for any engine load.

The power demand values were also used to estimate the associated landside power generation emissions using the following equation; as mentioned previously, this equation includes an adjustment in the hours to account for time spent connecting and disconnecting to the shore power system and transmission losses:

$$SPE = \sum PD \times SEF \times (1+L) / 1{,}000{,}000$$

Where:

SPE	= Shore power emissions for the landside grid (metric tons)
PD	= Hoteling Power demand (kWh)
SEF	= Georgia State emissions factor (g/kWh) obtained from eGRID
L	= Transmission losses (fraction): for the SRSO subregion, 0.0449
1,000,000	= Factor to convert from grams to metric tons

The net emission reduction was calculated using the following equation:

$$NER = AE - SPE$$

Where:

NER	= Net emission reduction (metric tons)
AE	= Dockside emissions (metric tons)
SPE	= Shore power emissions (metric tons)

Financial Elements

The power demand values were used to estimate ongoing energy cost associated with the implementation of the shore power system based on the contracted industrial rate with the Georgia Power Company at $0.07 per kWh. This cost estimate does not include cost to retrofit vessels or the required infrastructure changes needed to implement shore power at Garden City.

Auxiliary engine fuel consumption was estimated using the assumption of 203 grams of fuel per kWh data and the estimated power demand. The net cost savings for operators using shore power was provided using the assumption that vessels operating in U.S. waters are using global ECA compliant fuels at a cost of $663.50 per metric ton of MGO (approximately $0.13/kWh).[16]

$$CS = (TED \times 203/1000000 \times 663.5) - (TED \times 1.0449 \times 0.07)$$

Where:

CS	= Cost savings
TED	= Total annual energy demand for all vessel auxiliary engines (kWh)

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[15] U.S. EPA, Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, 2009.

[16] NY Price of ECA compliant fuel, August 21, 2018, https://shipandbunker.com/prices#MGO

203	= Grams of diesel fuel/kWh
1000000	= Conversion of grams to metric tons
663.5	= Price of fuel ($/MT of fuel)
1.0449	= Adjustment to account for transmission loss
0.07	= Price of electricity to the port ($/kWh)

Results

This study indicates that using shore power at the Port of Savannah would result in significant financial and fuel savings as well as emission reductions particularly for NO_x, BC, CH_4, and VOC. Anticipated emissions reductions and financial savings were calculated as described above and can be found in Tables 4 and 5 below.

Table 4. Anticipated Reductions in Emissions with Shore Power compared to Marine Diesel Fuel

Garden City Terminal							
	NO_x	SO_2	CO_2	CH_4	$PM_{2.5}$	BC	VOC
Vessel Power Emissions (MT)	478.11	22.90	37,548.36	77.19	9.37	5.40	22.73
Shore Power Emissions (MT)	10.21	10.21	25,625.99	2.20	4.39	0	0.79
Net Emission Reduction (MT)	467.90	12.69	11,922.36	74.99	4.97	5.40	21.94
Percent Difference	-98%	-55%	-32%	-97%	-53%	100%	-97%

Table 5. Anticipated Monetary Savings Using Shore Power

Terminal	Marine Fuel	Shore Power	Savings	Percent Difference
Garden City Terminal	$7,269,502	$3,947,666	$3,321,835	46%

Conclusion

It is anticipated that dockside emissions will be increasing given the Georgia Port Authority's plans to enhance throughput capacity to 8M TEU by 2028,[17] impacting the local air quality of adjacent communities. As noted in this study, the application of shore power can significantly reduce emissions based on the current mix of Georgia's electrical power generating sources. Future net emission reductions are anticipated as renewable energy sources continue to be added to the local grid in GA.[18] [19] [20] Additionally, the price differential between what the port pays for electricity and current cost of ECA compliant diesel allows the port to set the price at a point that provides a cost savings to ship operators while still allowing the port to recover associated infrastructure costs.

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[17] Georgia Ports Authority, 2018, Georgia Ports Plan 8 Million TEU Capacity by 2028, http://gaports.com/media/press-releases/articleid/200/artmid/3569

[18] Inside Climate News, 2018, How Georgia became a Top 10 Solar State, with Lawmakers Barely lifting a Finger, https://insideclimatenews.org/news/14062018/georgia-solar-power-renewable-utility-scale-clean-energy-investments-2018-election

[19] Utility Dive, 2016, Regulators Approve Georgia Power IRP, Including Cost to Study Potential new Nuclear Generation, https://www.utilitydive.com/news/regulators-approve-georgia-power-irp-including-costs-to-study-potential-ne/423494/

[20] Cision PR Newswire, 2016, Georgia Power files 20-Year Energy Plan with Georgia PSC, https://www.prnewswire.com/news-releases/georgia-power-files-20-year-energy-plan-with-georgia-psc-300212305.html