Evaluating Emission Benefits from Using Advanced Storage at Commercial & Industrial Facilities in California

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Background and Overview:

As storage technologies continue to advance and enter mainstream applications such as frequency regulation and assistance with integration of renewable technologies, the performance characteristics that drive the advancements reveal additional innovative uses of the technologies. This is the case with customer-sided applications of storage, where storage may have the opportunity to serve as a Commercial & Industrial back-up power and demand response tool. Such applications have the potential to provide benefits not only to the customer, but also to society in the form of benefits such as emission reductions. In addition, the application may provide a potentially large, untapped demand response resource for the state of California.

An example of a storage system that may be used at a Commercial and Industrial Facility is shown below in Figure 1.

Figure 1: Example of a Utility-Scale Storage Device that may be used for back-up Power

Project Objectives:

The objectives of the effort were to model and quantify the emission and pricing benefits of using advanced storage for customer-sided applications at Commercial and Industrial facilities in California. These benefits were in the form of emission savings in CO_2 and NOx over the current case where diesel back-up generation is used. In addition, benefits in the form of market pricing will be calculated if storage can be utilized as a real-time demand response tool. This benefit is measured by the total societal $ savings that may be obtained from the use of storage during key pricing periods.

The objectives of the study were met by conducting the following steps of (1) Assessing the use of Storage as a Back-up generation device, (2) Assessing the use of Storage as a Demand Response tool, and (3) Quantification & Compiling of Data as well as assessing pricing potential savings.

Approach Used in the Study:

KEMA utilized its proprietary KERMIT model for the study. KERMIT is a real time simulation tool that has integrated storage variables into grid systems for the U.S. In our study, KEMA first focused on gathering the data for each of the objectives and for inputs into the KERMIT model. The Energy Commission provided KEMA with a list of back-up generators in the State of California. The research team then divided the data into four regions to allow the model to target and tailor the impacts to each of the regions in the State. These regions were classified by the San Francisco Area, Los Angeles Area, San Diego Area, and are of "Other" territories which examined mainly northern regions of California and the Sacramento Area. The total MWs of back-up generation listed in the Energy Commission data base totaled approximately 3,800 MW.

Back-up Generators: KEMA utilized the California Energy Commission data on the number and location of back-up generators in California. For each of the generators, estimated emission factors were gathered from the database and confirmed with industry standards. As SO_2 has been greatly reduced in fuels, the study focused on CO_2 and NOx in our analysis of the generator emissions.

After the itemization of the back-up generators, the research team then focused on itemizing storage, outage, and demand response data that would be utilized in the model. An excel spreadsheet was created in order to line up the cases that were going to be run for objectives 1, 2, and 3. This data was set up by the research team in the following manner.

Storage: The main characteristics of the storage devices were the duration and efficiency. It was assumed that for each case, the proper amount of capacity of the storage device would be available. Hence, our model was set up to run separate cases of storage for 70% and 90% efficiency.

The duration of the modeled storage device was also set for multiple cases of model runs. Storage durations were selected for 30 minutes, 1 hour, 2 hours, 4 hours, 8 hours, and 12 hours. The durations were selected to represent battery technologies that may be used for this application. Hence, for the systems that ranged from 30 minutes to 4 hours, the research team used efficiencies of 90% (round trip). For storage devices that ranged from 4 hours to 12 hours, the research team used efficiencies of 70%. With the model's ability to run multiple cases, the durations were also selected in order to measure the ability of a storage device to respond to various outage requests and scenarios.

Outages: The back-up generation devices were grouped per utility areas in order to allow the research team to estimate outage information. An itemized list on each area's specific outage occurrences was not publicly available. Hence, in an excel data sheet, KEMA examined utility SAIFI (System Average Interruption Frequency Indexes), the top incidences in each area, and then created a frequency spectrum based on the probability that an owner of a back-up device would face on outage from the spectrum. SAIFI data from the last 10 years were utilized and averaged. An example of the sample of typical events is shown below in Figure 2.

	SF Area		LA Area		SD Area		Other	
Event	Duration (Hr)	Probability	Duration (Hr)	Probability	Duration (Hr)	Probability	Duration (Hr)	Probability
1	0.08	59%	0.3	80%	0.3	59%	0.3	58%
2	1.0	27%	3	13%	3	27%	3	8%
3	5.0	7%	7.5	3%	7.5	7%	7.5	35%
4	10.0	3%	12.5	1%	12.5	3%	12.5	0%
5	15.0	2%	17.5	1%	17.5	2%	17.5	0%
6	20.0	1%	22	0%	22	1%	22	0%
7	24.0	1%	36	1%	36	1%	36	0%
8	48.0	0%	60	0%	60	0%	60	0%
9	72.0	0%	84	0%	84	0%	84	0%
10	96.0	0%	108	0%	108	0%	108	0%
11	120.0	0%	132	0%	132	0%	132	0%
12	144.0	0%	156	0%	156	0%	156	0%
13	168.0	0%	192	0%	192	0%	192	0%

Figure 2: Sample Set of Events and Probabilities that were used to Characterize Outage Scenarios

Demand Response: For each of the territories, the research team examined all the Demand Response events over the last year to replicate what a typical C&I facility would encounter in each area. Incidences were categorized into 1-4, 4-6, and 6-8 hour blocks, with estimated MW totals and number of occurrences for each of the categories per areas designated.

For the study, only facilities that already had back-up generators at their facility (BUGs) were included as participants. The reason for this was because for the purposes of the study, the assumption was made that a facility would not deploy a storage device just for the sake of participating in demand response. Rather, there would need to be a compelling reason for the device to be there in the first place, such as the need for back-up generation. Hence, only facilities that were currently listed as having a back-up generator, and the equivalent BUG MWs of those generators, were included.

Pricing: Pricing was an additional investigation and modeling area due to the number of MWs of back-up generation that can potentially be available in California. As storage may be considered a low emission device, it is conceivable that these devices, if located at Commercial & Industrial facilities, may also be allowed to participate in demand response events. If so, the real-time introduction of possibly 3,800 MW of demand response into the system is expected to have a price impact in California, providing societal benefits that may translate into lower costs for ratepayers in the State.

Pricing data for the last year was obtained by the research team for use in the data gathering stage. In the model, with storage devices replacing the back-up generators, the KEMA research team then set up cases to estimate the price impacts of storage to lower prices during peak pricing periods.

The evaluation examined two areas of pricing support. The first area was the day-ahead demand response program, and the second area was examining the ability to participate in real-time load response in order to mitigate potential price spikes in general pricing.

Results of Assessments

With the data sheet set up with the proper variables and cases, the KEMA model was run in order to estimate, for each storage category of duration and efficiency, typical outage and demand response scenarios for California. The model simply estimated the number of MWs in which storage could be utilized in demand response and outages. For cases where a lower duration of storage was being modeled, such as 1 hour, the model utilized storage devices for as long as possible then had the remaining MW and MWhs contributed by the back-up generation.

For each case run by the model, the research team ran before and after cases for outages, demand response, and prices.

Outage Assessment:

For the outage assessment, the gains in emission savings are shown below in Figure 3. The result shows savings across the board. For smaller devices, such at the 30 minute devices, storage runs into difficulty because of the efficiency losses with many charge/discharge cycles that are required for the small efforts.

Storage Attributes		CO2 Emissions Savings				NOx Emissions Savings			
Efficiency	Duration (hrs)	PGE	SCE	SDGE	Other	PGE	SCE	SDGE	Other
90%	0.5	7%	10%	7%	7%	10.3%	21.2%	14.6%	12.7%
	1	13%	13%	11%	11%	18.5%	27.6%	22.5%	19.6%
	2	25%	19%	18%	19%	35.1%	40.2%	38.2%	33.6%
	4	40%	27.1%	28.6%	34%	57.2%	57.6%	59.2%	58.9%
70%	4	35%	18%	20%	26%	57.0%	57.4%	59.0%	58.7%
	8	48%	24%	26%	44%	77.7%	75.5%	78.7%	98.6%
	12	54%	27.2%	29.5%	44%	88.5%	86.3%	88.9%	98.6%

Figure 3: Summary of Outage Emission Savings

The devices seem to be maximized around the 4 hour duration – and as efficiencies of the units are a driver towards emission savings, the 90% devices show good results. Although intuitively it would appear that a 12-hour device could effectively act as an “infinite” storage, some outages exceed even the 12-hour duration and thus, inefficiencies occur due to the system being essentially oversized for the shorter duration outages.

Demand Response:

For the demand response, though the percentage improvements were roughly equivalent to the outages, the actual amount of reductions was much less due to the participation of devices. As diesel systems are typically not allowed to participate in demand response programs, the research team examined the MW total of natural gas back-up generators in the data set. As some diesel devices can be expected to participate, 5% participation of diesel generators was estimated. The results of the savings are included below in Figure 4.

Storage Attributes		CO2 Emissions Savings			NOx Emissions Savings		
Efficiency	**Duration (hrs)**	**SF Area**	**LA Area**	**SD Area**	**SF Area**	**LA Area**	**SD Area**
90%	0.5	4%	10%	15%	6.4%	20.4%	31.5%
	1	15%	16%	24%	21.4%	33.6%	50.6%
	2	24%	24%	37%	34.2%	50.4%	76.8%
70%	4	31%	27%	32%	51.1%	80.7%	98.3%
	8	42%	32%	32%	69.3%	98.7%	98.6%
	12	44%	32%	32%	72.5%	98.7%	98.6%

Figure 4: Summary of Demand Response Savings

Price Savings:

For the price savings, the two areas that were examined both showed savings. However, the "$/kW" savings that can be expected from day-ahead participation in demand response is a studied and calculated number for the state of California. Hence, simple savings calculations were made depending on the MW potential of the back-up generators at each facility. Though savings were also seen in the real-time response, the savings generated by the day-ahead participation were much greater than real-time savings. In addition, as it can be expected that greater participation in the day-ahead program will lessen the need for real-time requirements. For the societal savings, the summary is shown in Figure 5.

Region	Storage Capacity (MW)	Avoided Costs ($/kW-yr)	Estimated Total Value ($million)
SF Area	998	97.3	$97
LA Area	2083	90.7	$189
SD Area	470	89.3	$42
Other	330	92.4	$31
Total	3880	-	$358

Figure 5: Savings created from participation in Day-ahead Demand Response

Conclusions:

The conclusions of the study showed that savings were achieved in both emission reductions and dollar values for consumers. It is also noted that storage is not a full substitute for back-up generation. Storage is limited in its duration; hence, for full coverage, a combination of storage-generation is believed to be required. Though it can be said that this currently exists, in a new paradigm, the storage component would make up a much greater portion of the outage scenarios, significantly reducing the role of diesel back-up power or just limiting it to re-charging the storage device.

The study recommended that policies be put in place to encourage the use of storage for these applications. Improvements that can also be targeted are for increasing the efficiencies of the devices. Today, efficiency is more related to "Power" rather than "energy." However, research efforts should focus on increasing the efficiency of energy devices as well.