City of LOMPOC

City Council Agenda Item

City Council Meeting Date: October 3, 2017

TO: Patrick Wiemiller, City Manager

FROM: Tikan Singh P.E., Electrical Utility Manager
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SUBJECT: Adoption of Resolution No. 6143(17) Revision of Energy Storage Procurement Targets

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Recommendation:

Staff recommends the City Council adopt Resolution No. 6143(17) (attached) determining, at this time, it is not cost-effective for the City of Lompoc Electric Utility to procure energy storage systems into the distribution grid or to establish procurement targets for December 31, 2020.

Background:

On September 29, 2010, the Governor signed Assembly Bill No. 2514, which added Sections 2835-2839 to the Public Utilities Code (PUC). The purpose of that legislation is to integrate storage capacity into the electricity distribution grid.

Pursuant to PUC section 2836, the City of Lompoc (City) is required to determine appropriate energy storage targets. On May 15, 2012, in accordance with PUC subdivision 2836(b), the City Council adopted Resolution No. 5780(12) directing staff to initiate a study to determine appropriate energy storage procurement targets for December 31, 2016, and December 31, 2021, if any. Such determination must be reevaluated not less than once every three years after the first determination (October 7, 2014) was performed. The first three-year cycle ends on October 7, 2017.

Energy storage is defined in the legislation to mean “commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching said energy.” Furthermore, in order to be viable, energy storage must be cost-effective and either reduce emissions of greenhouse gases (GHG); reduce demand for peak electrical generation; defer or substitute for an investment in generation, transmission, or distribution assets; or improve the reliable operation of the electrical transmission or distribution grid.

Discussion:

Over the past three years, staff has reviewed several Department of Energy and Electrical Power Research Institute papers, documents, and reports. Staff reviewed information from technology assessments, market analysis, application assessments, and input from energy storage system vendors and system integrators. Additionally, staff participated in several meetings/seminars with other Northern California Power Agency (NCPA) member utilities, participated in energy storage webinars, and met with various equipment vendors. Recently, the City contracted with DNV GL to perform an Energy Storage Cost Analysis. The purpose of the analysis was to evaluate the viability and impact of integrating energy storage as well as cost-effectiveness methodologies that can be used to make storage procurement decisions. The findings of this research is explained below.

Potential Benefits of Energy Storage Systems

Some of the potential benefits of integrating energy storage systems into the City's electric grid are:

1. Load Shaving,
2. Electric efforts to reduce GHG
3. Substitute for an investment in distribution assets, and
4. Reliability.

Findings on the topics are discussed below:

1. Load Shaving

The primary purpose of energy storage is peak energy shaving or shifting energy demand from peak energy demand periods to lower energy demand periods when renewable energy, nuclear, and the most efficient (lower GHG emitting) fossil fuel generating stations are not operating at full capacity. This is desired in order to avoid constructing new fossil fuel generation facilities, and their appurtenant transmission interconnection facilities, and to avoid running less efficient and higher GHG-emitting generation facilities.

The City is located within the California Independent System Operator's (CAISO's) load-balancing area. CAISO's peak energy demand always occurs in the summer and was recorded at 46,232 megawatts (MW) on July 27, 2016. The City's energy demand, at the time of the CAISO peak, was 17.2 MW, or 0.037% of CAISO's total peak. Large investor and municipally-owned California utilities such as Pacific Gas and Electric (PG&E), Southern California Edison, San Diego Gas and Electric, and Los Angeles Department of Water and Power accounted for about 90% of CAISO's peak energy demand and are the primary drivers and targets of PUC subdivision 2835(b). Their service territories include heavy residential and commercial air conditioning and other large industrial motor loads.

CAISO's load factor, the ratio of average energy use to peak energy demand, is about 60%; the City's load factor is about 80%. Thus, the City's energy demand is more constant than the average CAISO member utility's energy demand. A peak event is considered to shift 20% from the baseline. Consequently, the cause of the difference in CAISO's average energy usage and peak energy demand, and, thus, the need for more fossil fuel generation and transmission assets, is larger utilities in CAISO's balancing area, not Lompoc.

2. <u>Electric Division's Efforts to Reduce GHG</u>

The City has already invested millions of dollars in renewable energy generation facilities, and currently receives about 25% of its energy from renewable bulk generation systems through our memberships in NCPA, Western Area Power Administration, Geothermal and Hydroelectric generation projects. Additionally, the City has already reduced its peak summer energy demand, through the City's Solar Photovoltaic (PV) net metering program, by 1.393 MW.

In addition, the Electric Utility has already developed a Renewable Energy Portfolio Procurement Plan and the Electric Utility is on course to supply 33% of retail energy sales with renewable energy (non-GHG emitting facilities) by 2020. Adding an energy storage system would not help the City in reducing GHG.

3. <u>Substitute for an Investment in Distribution Assets</u>

Distribution upgrade deferral involves using energy storage to delay or avoid upgrade investments that would otherwise be necessary to maintain adequate distribution capacity to serve all load requirements. Upgrade deferral may include replacement of an aging or over-stressed existing distribution transformer at a substation or re-conductoring distribution lines with larger wire. When a transformer is replaced with a new, larger transformer, its size is selected to accommodate future load growth over the next 15 to 20-year planning horizon. Thus, a large portion of this investment is underutilized for most of the new equipment's life. The upgrade of the transformer can be deferred by using a storage system to offload it during peak periods, extending its operational life by several years. If the storage system is containerized, then it can be physically moved to other substations where it can continue to defer similar upgrade decision points and further maximize the return on its investment. The average age for the City's existing transformers receiving station is 34 years. Although upgrade and replacement of the transformers will eventually be required, using an energy storage system is not a financially feasible method for increasing the life of the current equipment.

The Electric Utility does not need any new fossil fuel generation, only new renewable energy (non-GHG emitting facilities) to meet the Electric Utility's Renewable Energy Portfolio Standard procurement target. Additionally, the Electric Utility does not need any new transmission assets. Thus, it is not necessary to invest in energy storage to offset or substitute for an investment in generation or transmission. The Electric Utility does plan on investing in new distribution assets primarily to replace aging infrastructure and to gain additional operational efficiency, which will reduce distribution system energy losses and GHG emissions. New distribution infrastructure investments are also planned to meet new economic development needs, such as new commercial business facilities and new residential housing developments. These new distribution assets will be needed to provide a primary energy source to customers and would be required to provide a charging source for any potential energy storage system. Adding an energy storage system would not eliminate the need for critical upgrades and delaying these upgrades could prove more costly to the City.

4. Reliability

An energy storage system can effectively support customer loads when there is a total loss of power from the source utility. A system can be installed at the feeder level, such as community energy storage devices, or customer-sited behind the meter to pick up load when utility service is lost. However, in order to integrate a significant support the size of the system would have to range from 10 MW-25 MW. Implementing a system of that size would place a great burden on the fiscal impact of the utility as discussed in the Fiscal Impact section below.

The Electric Utility already has diesel generators at critical City facilities located throughout the City in the event of a transmission or distribution system issue. The Electric Utility has over 1,200 distribution service transformers throughout the City.

Energy Storage Technologies and Associated Costs

Currently there are five commercially available utility scale energy storage systems, they are:

i. Lithium Ion,
ii. Vanadium Redox,
iii. Flywheel Energy Storage,
iv. Compressed Air Energy Storage, and
v. Thermal Energy Storage

Each system is discussed below:

i. Lithium Ion

Lithium-Ion (Li-Ion) batteries utilize the exchange of lithium ions between electrodes to charge and discharge the battery. Li-Ion batteries are typically characterized as power devices capable of short durations (approximately 15 minutes to 1 hour) or stacked to form longer durations (but increasing costs). Rechargeable Li-ion batteries are commonly found in consumer electronic products, such as cell phones and laptops, and are the standard battery found in electric vehicles. In recent years this technology has developed and expanded its portfolio of applications considerably into utility-scale applications which, despite having very different requirements and features from consumer applications, benefit from the scale of manufacturing which lowers costs across markets.

Table 1 below depicts several key metrics and costs across different types of Li-Ion technologies

Table 1 - Cost Parameters and Metrics for Li-ion

Cost Parameter/Technology	Li-Ion NCM[1]	Li-Ion LFP[1]	Li-Ion LTO[1]
Energy storage equipment cost ($/kWh)[2]	$325-$450	$350-$525	$500-$850
Power conversion equipment cost ($/kW)[2]	$350-$500	$350-$500	$350-$500
Power control system cost ($/kW)	$80-$120	$80-$120	$80-$120
Balance of system ($/kW)	$80-$100	$80-$100	$80-$100
Installation ($/kWh)	$120-$180	$120-$180	$120-$180
Fixed O&M cost ($/kW yr)	$6-$11	$6-$11	$6-$11
Major Maintenance ($/kW)	$150-$400	$150-$400	$150-$400
Years between major maintenance	5	5	5
Installed costs ($/kW)	**$658-$1,980**	**$667-$2,483**	**$613-$2,780**

ii. Vanadium Redox

Vanadium Redox batteries (VRB), or Vanadium flow batteries, are based on the redox reaction between the two electrolytes in the system. "Redox" is the abbreviation for "reduction-oxidation" reaction. These reactions include all chemical processes in which atoms have their oxidation number changed. In a redox flow cell, a semi-permeable membrane separates the two electrolytes. This membrane permits ion flow, but prevents mixing of the liquids. Electrical contact is made through inert conductors in the liquids. As the ions flow across the membrane, an electrical current is induced in the conductors to charge the battery. This process is reversed during the discharge cycle. A general VRB system includes monitoring, control, and management systems, power converter/inverter, and the electrolyte tanks and stack of the batteries themselves. Table 2 below depicts several key metrics and costs associated with vanadium redox technology.

[1] NCM = Nickel Manganese Cobalt($LiNiMnCoO_2$); LFP = Iron Phosphate($LiFePO_4$); LTO = Titanate(($Li_4Ti_5O_{12}$)

[2] k/Wh = kilowatt hours; k/W = kilowatt

Table 2 - Cost Parameters and Metrics for Vanadium Redox

Cost Parameter/Technology	VRB
Energy storage equipment cost ($/kWh)	$500-$700
Power conversion equipment cost ($/kW)	$500-$750
Power control system cost ($/kW)	$100-$140
Balance of system ($/kW)	$100-$125
Installation ($/kWh)	$140-$200
Fixed O&M cost ($/kW yr)	$7-$12
Major Maintenance ($/kW)	$600-$800
Years between major maintenance	8
Installed costs ($/kW)	**$1,340-$8,215**

iii. <u>Flywheel Energy Storage</u>

A flywheel stores energy as the rotational kinetic energy of a spinning mass, i.e. the rotor. The rotor is accelerated by an electric machine acting as a motor during charging, and decelerates when energy is extracted (discharging mode) by the same machine acting as a generator. To reduce friction losses during rotation, in general, the rotor spins in a vacuum and magnetic bearings are used to keep the rotor in position. Table 3 below depicts several key metrics and costs associated with flywheel energy storage technology.

Table 3 - Cost Parameters and Metrics for Flywheel Energy Storage

Cost Parameter/Technology	Flywheel
Energy storage equipment cost ($/kWh)	$3,500-$5,500
Power conversion equipment cost ($/kW)	$350-$500
Power control system cost ($/kW)	$100-$140
Balance of system ($/kW)	$100-$125
Installation ($/kWh)	$2,000-$3,000
Fixed O&M cost ($/kW yr)	$4-$6
Major Maintenance ($/kW)	$200-$300
Years between major maintenance	5
Installed costs ($/kW)	**$565-$9,265**

iv. <u>Compressed Air Energy Storage</u>

Compressed air energy storage (CAES) stores electricity by compressing air into a reservoir and generates electricity by expanding the compressed air in a gas turbine. The compression is performed by a compressor unit. Depending on the type of CAES, the heat produced during the compression is stored or released into the atmosphere. The compressed air is stored in a suitable geological formation such as salt domes, aquifers or depleted gas fields. The compressed air is released for power generation; it is heated by combustion of natural gas and then expanded in the gas turbine. Table 4 below depicts several key metrics and costs associated with CAES.

Table 4 - Cost Parameters and Metrics for CAES

Cost Parameter/Technology	CAES
Energy storage equipment cost ($/kWh)	$10-$30
Power conversion equipment cost ($/kW)	$400-$500
Power control system cost ($/kW)	$100-$140
Balance of system ($/kW)	$100-$160
Installation ($/kWh)	$5-$10
Fixed O&M cost ($/kW yr)	$3-$5
Major Maintenance ($/kW)	$70-100
Years between major maintenance	4
Installed costs ($/kW)	**$660-$1,840**

v. Thermal Energy Storage

Thermal energy storage (TES) is a broad term for a variety of energy storage devices. It covers a wide range of very different technologies, wherein a medium is heated or cooled, and that energy is used at a later time. The energy to heat or cool the medium can come from the grid during off-peak times, renewable production that exceeds current demand, waste heat, or other sources. For the purposes of this report, the TES discussed is ice energy storage. Ice energy storage entails freezing water, or a water-based solution, at night to support space cooling during the day. The freezing process is conducted at night because lower ambient temperatures allow the ice to be made under thermodynamically beneficial conditions. Additionally, energy prices drop during the off-peak night hours. During the day, when temperatures and energy prices rise, the ice is melted and the cool air is circulated in the space. This can either reduce or eliminate the need for a conventional packaged air conditioning unit, dependent on the needs of the space and the local conditions. Table 5 below depicts several key metrics and costs associated with TES.

Table 5 - Cost Parameters and Metris for TES

Cost Parameter/Technology	TES
Energy storage equipment cost ($/kWh)	$200-$300
Power conversion equipment cost ($/kW)	N/A
Power control system cost ($/kW)	$80-120
Balance of system ($/kW)	$80-100
Installation ($/kWh)	$120-$180
Fixed O&M[3] cost ($/kW yr.)	$5-$7
Major Maintenance ($/kW)	$100-$125
Years between major maintenance	5
Installed costs ($/kW)	**$1,120-$3,100**

Cost for Load Shaving

The capital cost of energy storage equipment varies, based on the size of the facility and whether a single consolidated/centralized energy storage system is built, or if multiple/distributed energy storage systems are installed. The cost of equipment for a centralized target-sized of 20% of the City's peak load using a Li-ion NCM ES system (3.4 MW/6.8 MWh) is estimated to be $5.74 million. Energy storage system design and construction costs are estimated to be about $500,000 (for an existing electrical utility site) and annual O&M cost are estimated to be about $227,200 per year, which includes adding a new full-time employee at $200,000 and $27,200 for storage operation costs. The estimated life of the energy storage batteries, which are the bulk of the equipment cost, is estimated to be 10 years.

Cost for Reliability

Taking into consideration that the only reasonable usage the City can have for energy storage systems is assisting with reliability, a system of approximately 10,000 to 25,000 kW would be required to provide the City with power in case of loss of power from PG&E. Table 6 below depicts the fiscal impact of a potential 10,000 kW system installed and integrated to the local distribution system. Table 6 accounts only for the installed costs of the different options of energy storage systems. It does not account for additional land requirements, increased infrastructure (to commit the energy storage to the system) or additional personnel required.

[3] O&M = Operations and Maintenance Costs

Table 6 - Typical price for a 10,000 kW Energy Storage System

Typical system	Li-Ion NCM	Li-Ion LFP	Li-Ion LTO	VRB	Flywheel	CAES	TES
Size (kW)	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Duration (Hr)	2	2	2	2	2	2	2
Installed costs per kW ($/kW)	$ 1,690	$ 1,790	$ 2,265	$ 2,398	$ 14,658	$ 755	$ 990
Total Installed costs ($)	$16.9 M	$17.9 M	22.65 M	$23.97 M	$146.57 M	$7.55 M	$9.9 M

From Table 6 above, the cheapest option to provide the City with an energy storage system would be the compressed air energy storage technology at a cost of $7.55 million. However, from the previous explanation of CAES systems, a salt dome, aquifers or depleted gas field is required. Thermal energy storage would be the second least expensive option at $9.9 million. However, thermal energy storage is mostly used to support space cooling during the day, which is seldom required in Lompoc. Therefore, the least expensive and operationally viable option would be the Li-ion NCM energy storage system with a cost of $16.9 million.

Currently, the Electric Division is concentrating on converting remaining 4 kilovolt (kV) distribution systems to 12kV distribution systems for efficiency and reliability reasons, rebuilding old overhead 12kV circuits in the downtown area, and rebuilding 12kV underground facilities that are near the end of their service life. These are all capital and labor intensive projects, which are either ongoing or are multi-year projects with substantial work already completed. Without completing the projects, the efficiency and reliability goals will not be achieved. The 4kV to 12kV conversion project has been underway for several years and is anticipated to be completed in the next budget cycle. Estimated future budgetary savings to be realized after the completion of the conversion project have already been recommended to fund future costs of other distribution programs and would not be available to be used to secure an energy storage system.

Fiscal Impact:

There is no fiscal impact to the City, the City's General Fund or the City's Electric Utility associated with the passage of the proposed Resolution No. 6143(17) stating the determination that it is not cost-effective to set energy storage procurement targets at this time. However, if the City Council decided to fund a 10 MW/ 2.0-hour battery storage facility, the estimated resources required would include the following:

- Capital cost of at least $16.9 million (depending on location) for a ES with a 10 year life;
- $260,000 in increased annual O&M cost;
- The addition of at least one full-time equivalent position; and
- An additional $500,000 initial investment to provide interconnection for the ES to the existing distribution system (this is assuming a currently owned location is a viable option).

The cost of a 25MW Li-ion NCM ES system to fully cover the loss of PG&E's transmission source for two hours would be over $42.25 million, just for equipment.

Increase in retail Electric Utility Rates

Since the Electric Utility recommends funding current Capital and O&M programs at existing levels and the Utility cannot currently recover energy storage costs through participation in CAISO markets, the only viable funding source at this time would be increasing retail Electric Utility rates. A rate study would be required to evaluate the funding requirements to pay for energy storage costs through Electric Utility rates. The passage of Proposition 26 in 2010 prohibits the City from charging for services in excess of the cost of providing the services.

Conclusion:

With current cost figures, integrating storage capacity to the City distribution system would place a heavy financial burden that would directly affect the City ratepayers and the continuous operation of the Division.

Staff recommends adoption of City Council Resolution No. 6143(17), determining it is not cost-effective to develop an ES procurement target at this time.

Respectfully submitted,

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Tikan Singh P.E., Electrical Utility Manager

APPROVED FOR SUBMITTAL TO THE CITY MANAGER:

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Larry Bean P.E., Utilities Director

APPROVED FOR SUBMITTAL TO THE CITY COUNCIL:

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Patrick Wiemiller, City Manager

Attachment: Resolution No. 6143(17)