How to Efficiently Procure Battery Energy Storage Systems for Hybrid Energy Systems through a Tender Process

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***Abstract*—Battery energy storage systems (BESS) offer a viable solution for the integration of variable renewable energy (RE) systems. As hybrid energy systems (HES) they can substitute fossil-fuel based gensets both in on- and off-grid applications. As these systems have a high complexity in sizing and design, current tender documents vary in quality and given as well as requested level of information detail. For this paper, we analyzed 15 of the latest tender examples in various countries with a focus on request for proposals (RFP). Technical and non-technical information given as basis for an offer submission are investigated. Among others the typical sizes and applications as well as the services requested are further detailed. Additionally, we point out current challenges perceived in tender processes of BESS both as stand-alone plants and as HES. As a conclusion, the minimum requirements for an RFP that describes in a standardized form the use case and the desired result for the end customer is given. This shall subsume the relevant information for a comparable and solution-focused tender process.**

The goal of the paper and the presentation is to share knowledge for a more economic, techno-logical agnostic and performance focused procurement of BESS for RE based HES or stand-alone systems for a thus faster implementation around the world.

Keywords: hybrid energy systems, battery energy storage system, project experience, tender development, procurement

I. INTRODUCTION

In this paper we analyzed different tender documents that were requesting either hybrid energy system (HES) with a battery energy storage system (BESS) or BESS as stand-alone solution. A HES is here defined to consist of at least one renewable energy generation unit combined with a storage system. Technically this can be a combination of wind turbines and/or PV systems with or without a thermal generator (e.g. diesel genset or combined heat and power (CHP) unit). The focus of the study lays on the BESS component described within the tender documents.

HES with photovoltaic (PV) generators, wind turbines and BESS have been built to power isolated electric grids on islands (e.g. [1], [2], [3], [4], [5]) or as grid connected solutions (e.g. [6], [7] and [8]). One problem that was discussed among peers on the 4th Hybrid Power Systems Workshop 2019 on Crete, was the lack of standardization of the technological solutions as each hybrid system has different requirements to meet the local load profile, grid codes or individually requested energy provision. At the same time the sizes of the systems can be comparably small and thus lead to high cost for each project. Simultaneously, a variety of technological solutions is needed to deliver the best outcome for each use case. Likewise, the comparison between the different suggested solutions offered to a customer is quite challenging. Currently, complexity and needed comparability under non-existing standardization is a paradox, which is tried to be solved by highly complex tender documents. Results of high complexity paired with short time frames for responses reduces the number of possible bidders, excludes technologically viable solutions and/or result in incorrectly designed suggestions as replies on issued tenders. To foster more competitive processes, this paper presents lessons learned and recommendations for tender designs that lead to an efficient procurement of the most advanced solutions for (HES and) BESS under not fully elaborated circumstances.

II. THE TENDER PROCESS DEFINITIONS

In general, tender can be classified as the following requests by a possible purchaser or institutional body (“buyer”) addressed to a group of possible bidder/seller:

- Request for Information (RFI)
- Expression of Interest (EOI) or Registration of Interest (ROI)
- Request for Proposal (RFP) or Request for Offer (RFO)
- Request for Tender (RFT)
- Request for Quotation (RFQ)

The different request types have different purposes and thus different detail of information and expected commitment of the buyer. The wordings are sometimes used synonymously although they imply a different level of effort on the side of both buyer and bidder[1].

TABLE I. COMPARISON OF DIFFERENT TENDER TYPES AND THEIR IMPLICATIONS

	RFI	EOI	RFP	RFT	RFQ
Purpose	Get market feedback	Get shortlist of seller	Find seller for overall solution	Purchase best overall solution	Purchase best price solution
Level of detail on requested tech. solution	Low	Low	Medium	High	High
Level of commitment of buyer	Low	Low	Medium	High	High
Level of effort of bidder	Low	Low	High	High	Medium

Within an RFI typically general questions are raised based on an idea of a project. For the buyer this is an opportunity to make the possible future supplier aware of the project. From a project developer perspective within this phase the first contact is made, but no details on the final technological solution or prices are shared. From a technology provider perspective answering in more detail to the RFI could be beneficial to steer the direction towards a specific technological solution. A similar approach is the EOI but with a clear intention to shortlist parties that want to provide a solution to a not yet completely defined problem.
The RFP phase can use the information received during the RFI or EOI to build a more detailed request so that a solution suggestion and price indication can be given by a possible bidder. These projects have still some degrees of freedom after the bidder is awarded and the project is further developed. Thus, the prices given in an RFP are most likely to change during the detailed engineering phase of the project as the problem that shall be solved is typically not completely elaborated in the RFP documents.
Whereas, a RFT and RFQ have a precisely described problem and requests a solution that fulfills certain criteria. While a RFT can have a catalogue of selection criteria, a RFQ looks only at the best price option. In the following analysis the focus lays on RFP processes that include different level of services requested by a buyer. Common requested services are:

- Built Own and Operate (BOO) or Built Own and Transfer (BOT)
- Engineering, Procurement and Construction (EPC)
- Operation and Management (O&M)
- Project Management (PM)
- Project Development (Dev.)

The services above are ordered in decreasing depth of overall involvement and responsibility of the bidder. In a BOO concept the bidder is generally involved over the lifetime of the project, which includes the EPC phase and the operation phase, as earnings are only realized after the Commercial Operation Date (COD). The different services can be requested separately or combined within a tender. As an example, an EPC plus O&M tender requests the EPC services as well as after commissioning a maintenance provision.
The requested services require different level of information in the technical and non-technical category due to the different responsibilities associated (see TABLE II.).

TABLE II. OVERVIEW OF NECESSARY (MARKED WITH X) INFORMATION DEPENDING ON THE TYPE OF SERVICE REQUESTED FROM THE BIDDER

Type	**Power Size**	**Clear use case definition**	**Environmental conditions**	**Timeframe**	**Permitting**
BOO/BOT	X	X	X	X	X
EPC	X	X	X	X	-
O&M	X	X	X	X	-
PM	-	-	-	X	-
Dev.	-	-	-	X	X

For the further assessment we have analyzed the specifications given for the technical category “dimension and application” and for “Non-technical specifications” in each tender. The first category includes information on the “power size” as the required maximum power output, “battery technology” as the requested chemistry, the “system topology” as the pre-defined layout (e.g. voltage level) and “use case” with the given data for a detailed analysis of the required functionalities. In the non-technical category, the information of site conditions, permitting status, allowed timeframe and the quality of the received documents and response forms were evaluated.
Figure 1. gives an overview of the level of specifications given for each of the 15 tenders analyzed as well as an association to the system design and service type requested. From a developer perspective the categories power size, use case and all non-technical information listed above are the most important specifications that should be given in detail so that the purpose of finding the best overall solution can be fulfilled. Depending on the requested service in the RFP the level of detail can vary as described in section VI.
The overview shows that 9 of 14 RFP[2] have described the use cases in a way that allows conclusions on the correct system sizing of the BESS. But only seven (7) out of 14 have delivered sufficient site condition information. In general, improvement can be made on the segment of non-technical specifications given in tender documents. Additionally, reducing the pre-set requirements on battery technology (seven (7) out of 15) and topology would result

[1] Bidder can be one single entity or a consortium of companies that want to sell the services requested in the tender documents.

[2] There was one RFI and here the use case description is not a pre-requisite at this stage of the tender process

in more competitive bids as it would not exclude solutions in the first place. It would also allow the bidder to optimize designs based on the described use cases.

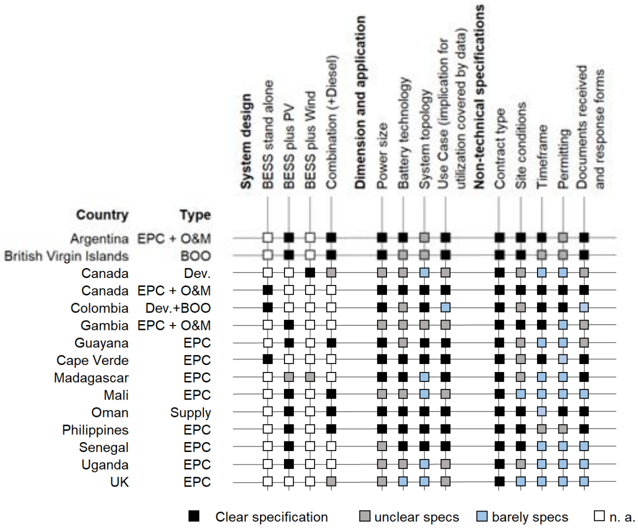

Figure 1. Overview of considered tenders by country and level of specifications given in three categories

Within the next sections, background information on the here investigated tender documents are given regarding the country, the requested project sizes and applications, the expected time frames, given head of terms and the given and requested detail of information. Based on the experiences made, the last section suggests a minimum standard of information for different tender phases and head of terms requested.

III. Project countries

For this paper, we analyzed 15 different request processes in terms of the technical as well as non-technical level of detail of the documents related to the battery storage system. The one (1) RFI (UK) and 14 RFP that were evaluated are distributed over five (5) continents; namely Europe, Asia, Africa as well as South and North America.

For Argentina, British Virgin Islands, Columbia, Gambia, Guyana, Cape Verde, Madagascar, Mali, Oman, Philippines, Senegal, Uganda, and UK one tender for each country was considered. Two evaluations were made for Canada.

At six (6) of these RFP ABO Wind or ABO Wind together with a partner handed in an offer. One (1) RFP is still under progress. At eight (8) RFP ABO Wind handed in no offer amongst others because of too much uncertainties regarding the technical requirements on the BESS. This circumstance motivated the further analysis.

IV. Project Dimensions and Requested Applications

The sizing of the projects[3] ranged from few hundred kW / kWh for off-grid micro-grids to a maximum of 45 MW and MWh for an on-grid stand-alone system. The average BESS size over the 15 projects is 9 MW / 9 MWh.

The BESS applications requested in the RFP included (1) grid forming, (2) grid investment deferral, (3) peak-shaving and (4) ramp rate control for micro-/island grid applications. Additionally, in the RFP documents (5) black start capability was explicitly requested two times. (6) Grid services such as fast frequency response (FFR) or secondary control power was not explicitly requested in any of the RFP, but from the description it became clear that the BESS would have to deliver such a service during operation.

Six (6) out of 15 tender documents did not clearly specify the reason for the sizing of the BESS. The BESS technology to be used was clearly defined in seven (7) of 15 RFP. In some RFP the cell chemistry was given without any reasoning for requesting this specific chemistry. A more competitive bidding process would be reached by opening the specification of cell chemistry and rather requesting references proofing that selected technology of the bidder can be applied in the desired use case and environment. At least in one RFP it was very hard to comply with the requirement of offering Lithium-Iron-Phosphate (LFP) cells because the project was with < 500 kW for 2 h duration too small for TIER 1 (first level) suppliers leading to the necessity to include suppliers with an unknown quality standard. One solution to overcome this issue of TIER 1 supply for smaller project sizes could be to combine project requests into one common request for several lots (tender program). Due to the higher complexity of sizing, design and procurement compared to non-HES projects, these lot sizes should be significantly bigger than standard RE projects so to offset the overhead caused by the higher complexity.

V. Timeframes

In general, the time schedule of a tender at RFP/RFT/RFQ stage should be set up to allow for questions and answers of the possible supplier and for proper evaluation in the first stage before handing in the offers. A first cycle of reading the sufficiently designed information packages allowing for question and answer (Q&A) rounds should be considered with minimum three weeks. It is reasonable to believe that a second clarification round is needed with one week duration. So, the issuing of tender documents and expectation of offers should be minimum four (4) weeks apart. The more complex the system design is and the more the issuer wants to have answers in pre-defined forms the longer the process should be designed.

Depending on the head of terms and the size of the project the time between acceptance notification and the expected COD should be carefully selected.

One should consider the current typical lead times of equipment requested:

- BESS: 6 - 9 months[4]
- Wind turbine: min. 9 months (better one year)[5]
- PV modules: 6 - 9 months

The duration until COD is also largely influenced by permits needed for erection (e.g. building, environmental and grid connection permit). Permitting depends on the country but should rather be considered as a long duration

[3] Referring to the BESS sizes as the requested RE size was not further considered for the purpose of this paper

[4] Lead times for BESS could increase in the future, if with increasing demand for battery cells from the automotive sector competition for sources with the stationary BESS applications arise.

[5] If wind speed measurements were already conducted for minimum one year and are available for the supplier

process with several months needed to get permits from official institutions. Therefore, the status of permitting is an important aspect that should be incorporated in the tender documents as a comprehensive list of permits identified with their status. In the evaluated documents this was often not the case and the time set between acceptance of the bids and COD was several times underestimated by the issuing party with durations smaller than the above-mentioned lead times. A good estimate on the realistic COD would however also reduce the cost of the project as the equipment could be ordered at a later stage and price degressions especially for BESS could be factored in the offering.

VI. Head of Terms

The head of terms (HOT) are the contractual conditions as they were described in the received tender documents. They should include the expected services of the contract (see II) as well as the suggested remuneration scheme and the financial background of the possible buyer, which can be different from the issuer of the tender. Especially for BESS systems where availability and performance characteristic are an evaluation criterion for payments during operation any penalties should be made transparent in the tender documents as they contribute to the finally offered price. This also includes the requested performance and warranty conditions. In general, the HOT and financial background of the buyer is especially for BOO/BOT contracts an important factor for the financial attractiveness of the project. This is because in these cases the seller and lenders are reliant on cash-flows after COD and thus the associated risk for the parties is higher. For a BOO a contract known as a power purchase agreement (PPA) is a pre-requisite for an evaluation and comparability of the offers. It should include the minimum duration of the service by the supplier after COD, a remuneration scheme (e.g. “pay-as-produced”) and a clear statement, if a sales transfer can be undertaken at a later stage.

From the 14 evaluated RFP, 10 have been EPC contracts with three asking also for an O&M service. Two were development including build, own and operate (BOO) contracts. The two remaining have been either a pure hardware supply or a pure development contract.

In one of the two BOO contracts the option was given to also deliver EPC service prices only. Here a draft PPA with minimum terms was only available at a later stage. The general description only stated the minimum expected years of the contract. Under unclear HOT the comparability of the offered prices, mostly given as price per kWh, is not given.

VII. Given and Requested Technical Information

The description of the system topology was in more than 50 % of the evaluated cases poor or non-existent. In general, the technical information received in the here investigated RFP documents were often very poor compared to the grade of engineering detail the issuer expected from the bidder.

In seven (7) of the evaluated RFP documents there was sufficient information about technical requirements for the BESS, Energy management System (EMS)/SCADA as well as on the interfaces between BESS and system/market operator allowing for proper sizing and price calculations. Seven (7) of the 14 RFP were isolated or micro-grid applications combined with thermal generators. Five (5) out of this seven (7) requests did not include load profiles with the tender and hold no information on the existing thermal units. On the other hand, the RFP issuer required in all seven (7) cases the integration of the existing thermal units into the BESS communication and control system. In another case the RFP issuer asked for a certain BESS cycle lifetime without specifying the charge/discharge profile of the BESS and gave no additional information to enable the bidder to calculate a preliminary service life (e.g. maximum number of cycles per year or day and maximum depth of discharges (DOD) expected). One RFP delivered very good technical details to prepare an offer in alignment with the expectation described in the RFP. Only the sizing of the BESS was not completely comprehensible but also non crucial for the requested EPC service.

Due to the inconsistent information received, it seemed that the responsible party for developing the documents have no expert knowledge on BESS, related certifications and Balance of Plant (BOP) hardware such as EMS, inverter or similar. As an example, in one RFP a certificate was requested which refers to lead-acid batteries, although the requested battery chemistry was a lithium-ion NMC. Additionally, the investigation showed that RFP issuer tend to include specific products (or even the product name) of hardware suppliers (e.g. for inverters or batteries) which makes a proper and competitive sizing impossible as only this specific product can fulfill all the requirements listed by the issuer. This should then be a RFT or RFQ process instead of an RFP, but the open engineering questions given in the tender would also not allow a direct hardware offer. For a technology-agnostic tender, we recommend focusing on a clear definition of standards and project specific details, the use case with minimum technical requirements and laying out the non-technical information. More emphasize should be given to clearly defined evaluation criteria for the system performance such as energy capacity, efficiency and availability of the BESS. The description should be clear and allow for a level-playing field so that the offers with different technical solutions can be compared correctly by the buyer. This will give a bidder the opportunity to design a proper and competitive solution best suited for the buyer’s defined use case. For this approach we suggest the following minimum standardized information for RFP tender.

VIII. Conclusion on Minimum Standardized Information for RFP Tender

The findings within the above-mentioned RFP examples illustrate current hurdles for bidders that need to be overcome for an efficient and competitive procurement process of BESS as stand-alone or HES. The authors suggest a stepwise approach with (1) a pre-feasibility study that should be technology agnostic and define the conditions and project specifics, (2) a RFI to find possible candidates through a quick request for interest giving first information on the points 1.-3. of the list below. And (3) an RFP to detail the technical conditions and define further the use cases. For clear definitions of performance relevant evaluation criteria, standards such as the IEC 62933-2-1 could be used [9]. For defining BESS specification, buyers

could make use of the EPRI ESIC standard documents for tenders (see [10]).
Additionally, for BESS RFP it would be a good approach to give the interested bidders access to all calculations made in advance by the issuer to enable the bidders to understand the sizing and to give feedback or recommendations as well as optimize the suggested solution with insight knowledge. In any case from the experience of the authors the following minimum list of information that should be given in a tender document to efficiently procure a BESS is recommended:

1. Heads of terms
    a. Scope of work and definition of services requested
    b. Renumeration scheme
    c. Performance and warranty conditions expected
    d. If BOO/BOT is requested the contract conditions with minimum operation duration and currency of payments as well as off-taker information should be included
2. Timelines and Project schedule
    a. Minimum timeline for RFP process of 4-6 weeks (with longer duration needed with higher complexity and risk profile)
    b. consideration of development steps needed and relevant lead times for equipment
    c. Giving information on the status of identified permits needed for the project
3. Location specific data:
    a. Geocoordinates and including information on altitude
    b. Environmental and climatic conditions (especially on temperatures)
    c. Available space and site layout (best with topographic study and/or site assessment report) or information on requested point of interconnection with the grid
    d. Transport access and restrictions especially for heavy weight
4. Functional requirements for BESS:
    a. Active and reactive power required at maximum load
    b. Energy/capacity beginning of life and throughout BESS lifetime
    c. definition of expected lifetime in duration and cycles
    d. definition of power quality and grid impact
5. Description of the use case:
    a. Required applications to be provided autonomously by the BESS
    b. Operation mode with (1) Grid forming operation, (2) parallel operation to other generators and methods for active and reactive load share
    c. Load profile that shall be served (min. resolution of 1h (better 15 min) for a year) with in best case future projection of changes in the load (esp. for off-grid)
    d. number of cycles expected in a year,
    e. generation profiles if generators are already existing
    f. in a HES with wind turbines: data from met mast or expected generation profile
6. Technical requirements
    a. Specific equipment requirements
    b. International standards requested
    c. Additional local codes, laws, standards and regulations (in particular grid code) to comply with as list and attachment
7. Definition of interface requirements
    a. Electrical interface
    b. Monitoring and control interface
    c. Protection interface

We hope to contribute with this list, references to existing standards and insights to a better understanding of information required in a tender from a bidder perspective. Furthermore, we hope to break down the complexity to a minimum so that more competitive biddings can be made. And thus, allow for more efficient RFP procurement processes and quicker implementation of BESS in the future.

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