Oral Discussions on Session: "Energy Storage and Distributed generation" – Part I

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Abstract

This paper contains the first part of the transcribed oral discussions of Session "Energy Storage and Distributed generation" of the 2013 IREP Symposium - Bulk Power System Dynamics and Control, held on Friday morning, August 30, 2013. Papers [1]-[3] were presented.

Discussion

Chair: Are there any questions from the audience for the presenters?

Misha Chertkov (Los Alamos National Laboratory): I have a question to the first speaker [1]. Two of my countries, US and Russia, invested heavily in gas infrastructure. And there's quite a lot of energy you can store in the gas pipelines. So, I wonder if you can comment on this option, whether it is feasible and how much we can count on that for power grid.

James Lyons (Capricorn Investment Group): That's an interesting question. I have not studied that in terms of packing gas pipelines and the like. Deutsche Bank published a detailed study on energy storage in Europe about a year ago. They went to the economics of the large-scale storage quite well. The one thing that they do recommend was R&D in methanation, the formation of natural gas and storing of natural gas as a way to go forward. The economics of that, in the Deutsche Bank study, does not work today, but they think it is a right area for research.

Fernando Alvarado (Wisconsin): I have two questions for Jim Lyons [1] and two questions for Elizabeth Ratman [3]. For Jim, what impact will storage have on congestion and congestion patterns and will headroom have to be allowed on congested lines, therefore reducing some of the available capacity, depending where the storage is located.

J. Lyons: I didn't quite catch the second part.

F. Alvarado: Will you have to reduce the capacity of lines to allow headroom for when the storage comes in, therefore, reducing the value of the transmission system by reducing the capacity available, since you now need that capacity to provide headroom for the storage.

J. Lyons: As you well know it is a complex answer to that and it is individual. I can think of two examples. There is quite a bit of thinking about transmission focused on wind in the US Midwest and West. And since the capacity factor of the average wind farm is 40%, building a transmission line to bring that to Minneapolis, or something, you'd like to fully exploit that line. So, there is a lot of thinking about integrating a storage facility right there to jack up the capacity factor of the line. So, in other words you overbuild the wind and store some of that energy, right? So in that case you are controlling your destiny on a specific line. If you look at Southern California, this pump-storage facility is quite complex. There are multiple lines in the network, you have wind farms, there is a couple of GWs of solar. So how to manage that it is quite a complex answer and congestion obviously will be an issue. One of the interesting things: if you go to the economics of that plant, energy is a small part of the economics. Buying energy at night and selling it in the day, you don't make money that way. So you need fast response storage so you provide ancillary services. The most valuable thing they have there is ramping services. And there is a lot of concern in California about the follow up of the afternoon load pick-up, when solar generation vanishes and the required ramp-rate to keep up with that is going to be extremely challenging. And that's in essence the new product that CAISO is trying to develop. How to balance all that, is quite a tricky problem. That's good news for you guys.

F. Alvarado: Lots of research opportunities!

J. Lyons: Exactly my point!

F. Alvarado: Now for Elizabeth [3]. Will time-of-use rates start adapting and changing in response to great penetration of photovoltaics? All of a sudden the utilities say: wait a minute, this time-of-use needs to change. Now

978-1-4799-0199-9/13/$31.00

our peak is, you know, at a different time. And the second question is: I am aware that some of the electric vehicles, e.g. Tesla, are specifically integrating extremely sophisticated charging mechanisms: you can program the car already very well on when to charge, how to charge, considering your rate structure. How would you integrate that into your thinking?

Elizabeth Ratnam (University of Newcastle): I am just trying to recall what your first question was.

F. Alvarado: The first question was: do you expect that utilities, as soon as you are successful with your time-of-use adaptive program to save money, next year they change it? Because all of a sudden now you have incentivized too much delivery of power at night. That's the first question.

E. Ratnam: In my future work I am planning to look at dynamic day-ahead pricing further and in this paper the problem is set up to do that. In the presentation I used time of use pricing as an illustrative example. Essentially I expect the utilities to change their pricing incentives and you would just update the pricing information a day ahead before scheduling the battery. Does that answer your question?

F. Alvarado: Yes, yes, it did. Basically you use time-of-use pricing as an example of how you can do…

E. Ratnam: dynamic pricing.

F. Alvarado: … dynamic pricing, but your approach is more general. If it changes, your programming will change.

E. Ratnam: Yes, definitely the paper caters for all of those scenarios.

F. Alvarado: And the second was really more a comment. If you have a smart car, with already smart charging, I presume your method for managing the rest of the storage will integrate into it whatever the car is doing.

E. Ratnam: So the motivation behind my paper was: if you did have an electric vehicle, would you want to use a percentage of that electric vehicle's battery for grid integration? So, it is essentially an algorithm of how to do that in an optimal way, based on the cost of electricity. So, yes, it is an alternative approach that we proposed.

F. Alvarado: Ok. Thank you.

Claudio Canizares (University of Waterloo): I have a question for the third paper [3]. A few questions, actually. Let me see if I've got this clear. You assume that the cost of battery is certain amount per kWh.

E. Ratnam: I don't assume the cost. I say, you give me the cost.

C. Canizares: Fair enough. So you assume that and you assume that to be constant.

E. Ratnam: No, you can insert in the paper any cost of battery and I'll find you the most cost-effective battery. So it is very general.

C. Canizares: What I meant was you don't change it with the capacity of the battery in terms of…

E. Ratnam: Yes, I can.

C. Canizares: It's a kWh, I understand that. I guess you could but in your examples...

E. Ratnam: My examples, I kept them very simple, but in the paper it definitely considers different costs for the battery.

C. Canizares: Fair enough. The other question I had is why do said quadratic programming approach as opposed to just minimizing cost?

E. Ratnam: My motivation wasn't actually reducing the cost of the electricity for the customer. It was a trade-off between the utility and the customer. So by minimizing π^2, the grid usage squared, the aim was to alleviate the grid from voltage issues like voltage rise and to also reduce peak power which helps the utility. So it is trade-off between the two, utility vs. customer.

C. Canizares: Thank you. My last question is: Can you modify your model so that, instead of doing heuristic search, the program actually tells you what the optimal capacity is?

E. Ratnam: That was planned for the next paper.

C. Canizares: Thanks.

E. Ratnam: Can I make one more comment? The reason we used the heuristic approach was just to see if there was any benefit at all before we went through the process of finding the actual optimum. When I started this research about a year ago, batteries were very expensive. Now batteries are being advertised on the TV for grid integration. Residents are buying batteries for their houses. So it has changed quite a lot in the last 12 months. Thank you.

Bernie Lesieutre (University of Wisconsin-Madison): Actually I was prepared to ask a question, but it is related to what Liz Ratnam just said and I was wondering if the other panelists could comment on the same theme: specifically, the difficulty in anticipating future technology adaption. Jim Lyons mentioned what is in the pipeline or what people are studying now, Elizabeth was just talking about we didn't expect batteries to be on-line but now they are coming very quickly. So, both from the consumer perspective and the utility perspective: how do you make long-term decisions with such uncertainty in technology adaption? So, I am addressing the panel.

J. Lyons: Clearly, as I pointed out, there is a huge amount of work going on in batteries right now. The progress and investment in lithium ion batteries is particularly spectacular. So, you can anticipate really dramatic cost reductions in the next several years. They are very well suited for the power applications that we talked about, because of their high C-rates and discharge rates. Certainly we are going to see this. We just pointed out that every middle class house in India has a UPS system and a battery already. When I was just talking about the 2/3 of the world doesn't have the developed world that US, Europe and Australia share, the creation of an energy battery that works and lasts 10 years, 10-20 years, is a critical technology issue for the developing world. We will see this happening. A lot of the developing world will be built around micro-grids in Africa. So this energy storage is critically important. And once we get the economics right, these micro grids will proliferate. We have an investment in a company in India that is doing solar-powered cell phone towers and they did 3,000-4,000 systems last year. Because displacing Diesels in remote locations is a no brainer in terms of return on investment. We will see how this will evolve in US and that, but my own take on this is if you have a solar roof, you are going to put a battery in your house. It's kind of the way people think about things. And you want to be able to charge Fernando's Tesla off his own roof, I know how he thinks about it... So I believe it goes hand-in-hand once the economics go right. Yesterday I received the business plan of a company that has exactly that product. You know, it's a household unit, you plug the solar in here, it has batteries in a rack, you can get lithium batteries or lead acid right now. So, you are going to see a lot more of that.

Franke Oldewurtel (ETH): I think there is no general answer to what is the best investment strategy for all countries. I think, as you pointed out before, one has to distinguish between developing countries where there are certain situations… Europe is different, US is different again, so I think what you have to do is to see what you have in a particular country and then go from there and start investing. And it's not one point in time when you make a decision. You actually start investing in some infrastructure, let's say you have a large penetration of plug-in electric vehicles at some point because you decided to go for that, then it also opens up more possibilities as you go. So you always have to keep on looking at the situation in your country and you have constantly to be evaluating what you are doing. I think this is a very complex question. You have to look at it over and over again.

E. Ratnam: So I have seen, from the distribution utilities in Australia, the more rural the network, the weaker the grid, the higher the benefit for battery storage, especially when there is PV in those grids resulting in voltage rise. In the north of Australia, we have what we call SWER (single-wire earth return) networks, as it costs a lot of money to build the distribution grid out there. So, utilities often turn to alternative solutions when augmenting this kind of distribution grid. They often install fuel cells and batteries in the grid out there. As the panelists said, it depends on the situation, where you are. Thank you.

Chair (Ian Hiskens): I'd just like to add, as David is getting the microphone, that my first job, after graduating as an electrical engineer, was designing single-wire earth return systems where there was, like, one consumer per 50 or 100 km of wire. So, it makes sense to look at doing other things, so … David

David Hill (University of Sydney, University of Hong Kong): I have a question for the second speaker [2]. It's a general question on people responding to price signals vs. the more interventionist approach as a means of achieving everything with demand response and storage. I wander if you have a general comment on how those two mechanisms interplay with each other. You showed some specific graphs, which I can't find in your paper at first glance, where I thought you were comparing price-based mechanisms and a control mechanism; is that right, with the commercial buildings? So, maybe you can use that to illustrate your general comment.

F. Oldewurtel: So you are actually asking about the difference between price based and…?

D. Hill: I was asking, can we solve everything by giving the right price signal or do we need to mix that, in a nutshell, with more intervention

F. Oldewurtel: Thank you. The picture is actually in the paper, so you can find it. It's actually a long paper, so no worries! So what we did there, was we compared the case where you are sending a price signal to all buildings and then all of them react to that price signal, with the case where you have an aggregator and the aggregator solves the central problem for all the buildings which are taking part in that aggregation. So now if you solve it centrally, obviously you have all information available and you can make the best decision possible theoretically. However, this is not fair to assume, because people will not possibly give you all information. So, this would require a lot of communication throughout the day, you would take measurements at each building communicated back and forth and that's why we said we want to solve this centralized problem first, to see what we can achieve at best in this set-up and whether the aggregation can actually fulfill this requirement, that it can actually balance out everything, and, as you saw, it was this straight line. So it worked out, the aggregation is capable of doing it. Then, we said you might actually think of set-ups where you are just communicating information once a day and you are storing information of priority at the aggregator. So, for example, you could think of things like storing sensitivities to price signals and then giving this information at the aggregator and giving a measurement day-ahead and you could then, as you go throughout the day, the aggregator could basically make up his mind which price signal to communicate. So there are lots of different things you can imagine. And I think this is an important research field and it's not clear what people are willing to accept in terms of measurements and how many measurements are possible.

D. Hill: Thank you. I have a question for Elizabeth [3]: Is there any benefit in looking at more general H matrices? This sounds like an adaptive control problem to me, in some sense, so following Fernando's comment we're going to have these H's chasing changing situations, so can you use learning techniques or …

E. Ratnam: In my future work I am looking at game theory for the financial aspect and model predictive control when looking at uncertainty in the predictions of load and generation.. Does that answer your question?

D. Hill: Yes, thank you.

Chair: So, we close this half of the Session right now. Coffee time and then we resume for the second half of the Session.

References

[1] R. Thomas, J. Lyons, T. Mount and R. Schuler, "The Multidimensional Character of Electric Systems Storage," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece.

[2] F. Oldewurtel, T. Borsche, M. Bucher, P. Fortenbacher, M. Gonzalez Vaya, T. Haring, J. L. Mathieu, O. Megel, E. Vrettos and G. Andersson, "A Framework for and Assessment of Demand Response and Energy Storage in Power Systems," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece.

[3] E. Ratnam, S. Weller and C. Kellett, "An optimisation-based approach for assessing the benefits of residential battery storage in conjuction with solar PV," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece.