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Oral Discussions on Session: "Optimization and DSM" – Part I

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Abstract

This paper contains the first part of the transcribed oral discussions of Session "Optimization and Demand Side Management" of the 2013 IREP Symposium-Bulk Power System Dynamics and Control Symposium, held on Wednesday afternoon, August 28, 2013. Papers [1], [2] and [4] were presented by authors. Paper [3] was presented by Guanqun Wang of Washington State University.

Discussion

Chair: We are open for questions.

Emmanouil Thalassinakis (HEDNO): My question - comment is to the third speaker [3]. The restoration process is a very difficult and very complicated one. So, it is very important that during this process we proceed with very secure and safe steps, in order to avoid causing a black-out. Because if this happens, the situation becomes much worse. We have to take into account a lot of parameters, which vary from system to system. For example, suppose that you have started one or two units and then you energize a transmission line. It is very possible during the energization, because of the line's capacitance, that a unit which has already started will trip, because this is a capacitive loading that can bring it out of its loading curve, so what we have to do is perhaps choose a short line or to energize the line together with a step-down transformer, or even better to put some loading and then to try to bring this first unit to very secure point of its operation. Because during restoration the system behaves much different than it behaves in normal situations. So there are a lot of issues: issues concerning the security of the unit, issues concerning the protection. So in my opinion, the problem will not be solved following just a logical process for the system constraints, as you presented.

Guanqun Wang (Washington State University): Thank you for your question. I am doing this presentation on behalf of Dr. Wei Sun, so actually this is not my work, so maybe I don't know clearly about his work. But I think from his paper, maybe I can answer this question, because I think in his paper the restoration process, as I said in my presentation is divided into three steps. The first restores the generators, the second the transmission lines and the third is to restore the loads. I think that means he will first energize the whole system without pick up the load and then after…

Andrea Mansoldo (EirGrid): This is the problem.

E. Thalassinakis: Exactly this is the problem.

G. Wang: Maybe I don't understand you very well.

E. Thalassinakis: You will never restore the system like this.

Shmuel Oren: It's like running your car in neutral and kicking the gas.

Chair: I don't think it's fair to ask the presenter to answer questions on behalf of the author, but the point is very well taken. I was wondering the same thing myself.

E. Thalassinakis: Very, very difficult process to restore the system, so it's not…

Chair: And it was not clear. I agree with you.

Janusz Bialek (Durham University): My question is to Steven Low [1]. You have restricted right from the beginning your problem to standard OPF. But the standard OPF is really only of academic interest, because what the utilities do and what happens is security constrained OPF which is N-1. I know you haven't done it, but basically what are your thoughts, to what extent, can you do it? I mean it is difficult enough to convexify just standard OPF. What are your thoughts about it? Is it at all possible? What would be the way to do it and any possible problem toward a security constrained OPF?

Steven Low (Caltech): We haven't done it and therefore all is speculation. I think security constraints can be handled. You just need more variables but I think the basic structure remains the same. The thing that we don't have

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really any idea is, if it includes discrete variables. Then this approach doesn't address that problem at all. There are other techniques one may be able to combine but this, the convex relaxation approach I described, will not address the discrete variables. A security constrained I think can be done.

A. Mansoldo: A follow up of your question which actually, the third paper [3] had some future work, maybe in that sense. But I want to translate it to the second paper, Anthony Papavasiliou's paper [2], because a similar issue may be found also switching off and on components in a grid that is in operation. And we are struggling a lot to understand the issue from the EMT point of view, in terms of grid assets that may have some potential resonances, especially when we have to install cables and we have to, probably in the future, deal with a lot of undergrounding and this makes the problem worse. So I wonder if some of this issue could be addressed somehow in this constraints' analysis, but the grid assets, which from a steady state point of view may be very good, could be then in a following hour not suitable to make the other grid asset option. So I don't know if you tackled the issue or you are going to do so. But this is another issue, we feel.

Anthony Papavasiliou (Catholic University of Louvain): I think that a source of the difficulty in the problem is having too many lines to switch and if you want constraints in lines that you are not sure if you want to switch them or not, because of the impacts on the dynamics, that can easily be incorporated in the model. The difficulty in solving the problem is that you have too many options in the first place. In fact the third algorithm I showed you with the groups is actually doing that. You partition the entire network into mutually exclusive groups and you say "OK, let's suppose now that I can work with this group. What is the best I could do?" So you can isolate groups of candidates that you would like to switch and what the model does for you, it does it in a systematic fashion. I don't know if that helped addressing your question.

Tasos Bakirtzis (AUTH): I have a question for Tony Papavasiliou [2], as well. Tony, have you considered the implications of transmission switching on nodal prices and on FTRs? Also, what is your opinion on operator acceptance of transmission switching especially in North America?

A. Papavasiliou: The disclaimer is that I have worked exclusively on the parallelization of the computation, so best qualified person to address this question is probably Kory Hedman who along with Shmuel Oren have worked on examining the implication on FTR markets. To answer your question specifically, no I have not looked at LMPs and I have not looked at FTRs. My view on this, to the best of my knowledge, is that the existing FTR paradigm can probably not easily accommodate topology control but then again FTRs themselves were a completely new market design, it was a good market design that was invented to adapt to the technology of the time. Now in this new paradigm, suppose we had hardware and the operators who were willing to actively control lines, I think it's best if the market design adapts to that, instead of inhibiting that because of the market design. So to follow up on that, for example with unit commitment we have the same problem. It is an integer decision. And you know Scarf back in early '90s proved that there are no market clearing prices for integer markets. But we deal with it, we deal through make-whole payments, so market design is adapted to technology when technology can deliver benefits and the ultimate argument is that if you can make the pie bigger, by creating greater efficiencies, then everyone can walk out happy from that. It does create winners and losers probably, but the overall benefit can be allocated.

Chair: I am going to allow Shmuel Oren, coauthor of [2], to step in for a moment. I think he has something to add.

Shmuel Oren (UC Berkeley): Actually Tony addressed the issue. When we design a market, we should not let the market design inhibit superior technology because it doesn't quite fit. We can always come up with transfer payment mechanisms that are going to spread the wealth once we increase the social welfare of the solutions. In that respect, FTR markets will have to deal with that. I mean even today, FTR markets deal with the fact there are revenue inadequacies because sometimes you have line outages. So there are mechanisms that are in place to deal with the revenue inadequacy. Now I would also like to address the question that was raised before about line switching. You know the philosophy that we are adopting is that system operators are switching lines, as part of the way they deal with problems. In PJM for example, I was talking to Andy Ott, the vice-president there, they switched lines to deal with some voltage problems that they had; but they do it on an ad hoc basis. . So, that's what we are trying to do. In addition in the United States a lot of lines are now being built, especially with the renewable penetration for economic reasons, not just for reliability reasons. So if we are able to build lines for economic reasons, there is no reason to treat those lines as a fixed asset. What we are trying to do now is to push the idea the transmission can be re-configurable, especially if we start to build more lines and to introduce redundancy for market reason, and that's what we are trying to accomplish, to do that in an optimal way rather than doing it on an ad hoc basis.

Thanos Koronidis (IPTO): The question is again to Anthony [2]. I cannot really understand the natural issue behind the mathematics. I cannot find many reasons, even if I have too many lines in the system, why by switching off lines I get a better performance, or I get some cost reduction. Unless I am trying to solve some specific problem, which can be too high voltages at low loads, or some loop flows that are created by some lines existing here and there. But in principle, I don't see how by switching lines I get results with better cost.

A. Papavasiliou: I think that in highly meshed networks, it's probably too complex for the human brain to identify patters, but if you run it as a mixed integer linear program you can see such cases, especially for the static instance of the problem, without security constraints, without multi-period constraints. I believe Kory showed that there is a 27% cost improvement for instance of the problem, no security constraints etc. So as a mathematical problem it's definitely possible, there are patterns there that you can exploit and a simple intuition behind it is that you would think intuitively I am removing a line that reduces my control, it is making things worse, but in fact because of Kirchhoff's laws, lines become indirectly control variables because they re-allocate the flows in the network. There are simple three-node examples where you can show how it can help, and those were part of Kory's job and the bottom line is you can only believe it after you see it and it's the output of a systematical formulation in a math programming software. So for highly meshed networks where it is difficult to identify these patterns, I think the best answer to your question is that you can only believe it after you've seen it. And of course when you add security constraints, because Kory did that, and things become more restricted and you add multiple time periods this 27% improvement falls down to maybe 2%. But still 2% in a billion-dollar market is a substantial amount of money.

T. Koronidis: Are you sure this is not a numerical error?

Chair: I am going to use the chairman's prerogative to add a little bit to that comment, because I happen to know a little bit about this. Think of putting a 69kV line in parallel with the 500kV line. In effect you will always get the congestion on the low voltage line and if you remove it, nothing is going to happen and you are going to get a much better operating system. And if you want an older reference, I think Hans Glavitsch and Rainer Bacher [5], quite a few years ago, had an excellent kind of first paper on the subject many years ago. Well, next person. Back to my job.

Bernard Lesieutre (University of Wisconsin): A question for Christine Chen [4]. Very interesting! Very neat stuff! I liked it a lot. My question has to do with generators. When you calculate sensitivity, how do you distinguish between a generator that is off and one that just has very firm constant output? And you mentioned an application that you may use this for re-dispatch of generation to respond to events. It would be important to know whether a generator is there to respond. That's my question.

Christine Chen (University of Illinois): Thanks. My first intuition is to say that we haven't really thought about it, in terms of how that would come about, since it is an application we haven't explored. But I wonder if it is possible to deduce from the past data that the PMU sends from the generator that you are looking at, whether it is constantly zero or some external information or historical information that we can deduce.

B. Lesieutre: It's probably likely that most generators will have PMUs and you might get a direct measurement that way. I was thinking you have this example when you lose a line and you don't know it, you automatically update that, and it's great, that's fantastic, but it seems that the parallel is not quite there for the generators, if you don't have direct knowledge.

C. Chen: Right. If you lose a generator, whether it's lost or whether it's just turned off...

Bernard Lesieutre: Or in terms of sensitivity analysis, if it's just perfectly constant output you don't get the sensitivity.

Jim Lyons (Novus Energy Partners): I want to get back to the question on topological control [2]. You had a slide that showed these new distributed reactors that are being developed in pilot form right now. Have you looked seriously to what it would seem to me more of a continuous type control as opposed to discrete shutting off lines? Maybe this is a superior way to really optimize the generation mix and relieve congestion. Can you comment on that please?

A. Papavasiliou: You are exactly right. The variant of the problem, which is why it is not exactly the same problem, is that it becomes a continuous optimization problem where now the susceptance becomes a decision variable, whereas if you noticed in the model I presented, it was a fixed parameter, what the network characteristics are. When you have FACTS devices we assume that the way to model that is we are changing the B parameter, so it becomes a control variable, and that becomes a non-linear optimization because that's multiplying the bus angles, but there are ways to deal with that, which we are going to be exploring. I believe that's a much easier sell for practitioners than switching stuff on and off.

J. Lyons: Yes. That was what I would conclude.

A. Papavasiliou: The idea is that it becomes a nonlinear optimization, but under certain assumptions, for example if you know to which direction the flow on the line is, you can have a linear re-formulation and deal with it efficiently. That's work in progress actually.

Ian Hiskens (University of Michigan): I have a question for Christine Chen [4]. Maybe I missed it, but you need some kind of exponential forgetting factor. If you just keep adding more and more measurements and there is a topology change that occurs, there is going to be some skewing, some pre-contingency, post-contingency type of behavior. So, that's the first question. Actually I have a second question for you as well. So, this reminds me a little bit of a phenomenon in adaptive control, "persistence of excitation", where if things go very steady for a long time you can get the gains that kind of blow up, then when something does come along, you end up with massive overshoot. So in your formulation with your linear least squares that would show up as rank deficiency or near rank deficiency. So you would need to be careful to check for that to have sufficient persistence, sufficient excitation in the measurement.

C. Chen: In terms of the first comment with the least squares, we currently have another paper in review actually, in the Transactions where we extend this work and we do actually use the weighted least squares formulation.. The most important reason for it is that for example if there was some kind of change in operating point, like a generator ramped up, or something like that, we actually would want to forget the previous operating point when it was down here, and have more weight on the more recent data which is why we used the weighted least squares in the extension of this work.

I. Hiskens: Can I just ask a clarifying question? So when you are building up your measurement matrix do you have a sliding window. Do you just add more and more measurements, or do you always have a sliding window?

C. Chen: In this simulation we have a sliding window, as well as adding more measurements. And we actually implement this recursively, so with each additional measurement we are not taking a giant matrix and invert it. We are doing it recursively.

Yannis Blanas (IPTO): I was positively surprised with this effort to optimize the restoration process [3] which is a very difficult and very important process, but it does not happen very often. I have the feeling, and of course the author is not here, I have the feeling that I want to convey that the problem is very complex. I have worked for many years in operations and I have some experience in restoration from total black out. Usually the restoration is done in islands. There are a lot of parallel processes in order to restore the whole system. Also it is very important that there are priorities to supply specific loads that are sensitive to the duration of interruption. My understanding is that there is a lot of room for future work and it is important to consider these remarks for any development. But it is very important to start this optimization.

G. Wang: Thank you. Do I need to give an answer?

Chair: I think that was more a comment. Thank you very much.

S. Oren: This is a question to Steve Low [1]. When we solve the OPFs and use successive linearization we have some very useful price information that comes out of that, because we solve the DC approximations and we get shadow prices and those can be used as LMPs. Do you see any useful price information coming out of the conic relaxations that you are using?

S. Low: Again it is speculation at this point. I think, if we can reliably rely on convex relaxation, which means we indeed solve a convex problem, then I think the Lagrange multiplier would be naturally usable and perhaps even more reliable than the Lagrange multiplier from the DC OPF. If the convex relaxation is accepted, what it means is that the problem with the physical system is non-convex, however, it shares the Paretto Front with the convex problem. And therefore you can just equivalently solve the convex problem and the Lagrange multiplier we have has the usual meaning of economic theory. Whereas in the non-convex problem it's not clear what the Lagrange multiplier means. In the DC of course we always get Lagrange multiplier, which is extremely useful. For most cases I imagine it is informative and useful and we have been using that. The issue is: are there situations where the DC approximation is a problem itself. Then the Lagrange multiplier that follows from that may create issues.

Chair: OK. Are there any other questions or people would like to go to the break just a couple of minutes early? I can sense that everybody is ready for the break. So, I will adjourn this part of the session and since we are a few minutes at the front let's finish the break earlier. I will call you back with the bell.

References

[1] S. Low, "Convex Relaxation of Optimal Power Flow: A Tutorial," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece

[2] A. Papavasiliou, S. Oren, Z. Yang, P. Balasubramanian and K. Hedman, "An Application of High Performance Computing to Transmission Switching," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece

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[4] Y. Christine Chen, A. Domınguez-Garcıa and P. Sauer, "Online Computation of Power System Linear Sensitivity Distribution Factors," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece.
[5] R. Bacher, H. Glavitsch, "Loss reduction by network switching," IEEE Transactions on Power Systems, Vol. 3, 1988, pp. 447 – 454.