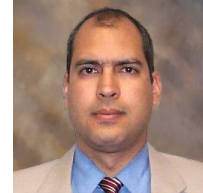




Reliability Rules!



Ramón Nadira
Senior Manager Consulting
ramon.nadira@siemens.com



Carlos A. Dortolina
Senior Staff Consultant
carlos.dortolina@siemens.com

Worldwide, the electricity industry is undergoing significant changes with regards to its structure (i.e., vertical separation of generation, transmission, and distribution companies), its ownership (i.e., participation of privates in transmission), and its regulatory mechanisms (e.g., establishment of autonomous regulatory entities). These changes are having a significant impact in the way transmission networks are planned and operated. We argue in this article that unless the technical, economic, and regulatory aspects of transmission systems are given equal billing, the restructuring efforts are likely to encounter significant difficulties. We also suggest that reliability criteria should be output-based rather than input-based, as has traditionally been the case.

Introduction

The restructuring of the electricity industry in many countries has not only meant that utilities have been unbundled - both vertically and horizontally - but also that the way we look at power systems needs to be restructured as well. Now more than ever, one must recognize that the technical (i.e., physics), economic (i.e., commercial), and regulatory aspects of the industry are intertwined, and that decisions cannot be made in isolation. As such, engineers, economists, and lawyers need to start speaking the same language, and need to become ever more cognizant of each others' sphere of influence.

An illustrative example of the above is the reliability criteria that are currently used - almost universally - to plan and operate power transmission systems. We are referring here to the common set of transmission planning and operations criteria known as "n-1". These criteria, which are of a deterministic type, prescribe that the power system must be able to operate within equipment thermal and voltage ratings in the event of an unscheduled outage of any single element, such as a transmission line, a transformer, or a generating unit¹. In other words, the system must be able to withstand any single contingency event even if such occurs at the worst possible moment. In addition, the criteria provides for stable operation following transient disturbances caused by a single independent event, and cleared by automatic equipment. Specific "n-1" criteria are developed by each of the NERC² reliability councils, and are applied by the member utilities in their own planning studies. These guidelines may be modified (in general this means made more stringent) to accommodate regional practices and procedures.

Adapting the above "n-1" criteria for the restructured electricity industry has proven to be a difficult task. Reliability rules! Arguably, this is because being such a technical, deterministic approach, "n-1" does not fully recognize the economic and regulatory implications of planning and operating a transmission system. Therefore, incorporating these economic and regulatory implications is rather difficult, if not impossible.

The Challenge

Formulating reliability policies and criteria that meet technical, commercial, and regulatory needs requires an essential transformation of the way planners and operators regard the transmission system. Interestingly enough, recent efforts appear to implicitly underestimate the importance of the technical side of things, in favor of economic and regulatory considerations. How else can one understand all of the discussion about congestion management via financial instruments, when congestion **itself** is a function of the reliability criteria adopted? In other words, before even attempting to propose financial congestion management solutions, doesn't it make sense to question whether congestion is properly defined? A similar situation applies to determining transmission use.

Properly taking into account the three dimensions discussed above - technical, commercial, and regulatory - is by no means an easy task. First, there are the laws of physics³, which apply in a nondiscriminatory fashion to all⁴. For one thing, a power system is an integrated "energy-conversion machine"⁵, and as such, its various components (i.e., generation, transmission, and distribution) are strongly coupled from a functional viewpoint. For example, transmission transfer capability is a function of the generation dispatch as well as of the location and size of the load demand. Further, transmission systems do not behave – and therefore cannot be properly modeled - as transportation networks⁶; power flows in a transmission system do not follow contract paths. The laws of physics and the non-linear response of system controls are important. On top of this, since system conditions are continuously changing, the requirements on the transmission grid also change continuously.

Then, there are the ever so important *economic* considerations. It is quite challenging to calculate the costs and benefits associated with a transmission plan, in part because it is hard to functionally separate generation from transmission from distribution. Further, except for DC ties and in the simplest of cases (such as radial systems), it is incorrect to attempt to calculate the costs and benefits of individual transmission projects. These costs and benefits accrue to the entire plan and are virtually impossible to allocate to the individual projects. Further, it is generally the case that a transmission system cannot improve its reliability without additional investment. The opposite is not necessarily true, though.

Finally, there are *regulatory* considerations to contend with. Modern regulatory thinking is moving away from input-based regulation towards output-based (or performance-based) regulation. Measuring the performance of a transmission system is by no means simple. Providing the appropriate incentive signals to expand transmission is not simple either.

Output-Based Criteria

In our opinion, the way to reconcile the above differences is to move away from prescriptive, input-based, reliability criteria, and instead adopt output (or performance) based criteria (see Figure 1). One possibility to do this would be to establish standards of performance for transmission systems, and penalties for non-compliance with these standards.

The standards would be composed of at least two elements: (1) performance indices, and (2) minimum acceptable targets for each of these indices. Examples of performance indices include frequency, duration, and severity of unplanned outages at predetermined supply points. This presupposes that the transmission company is able to expand its system at will, since otherwise it is being forced to comply with a given standard without the concomitant ability of improving its performance. When the transmission company is not able to expand its system at will, a sub-optimal possibility is to set standards based on the reliability of each of the components of the transmission system⁷.

Adopting output-based transmission reliability criteria as described above offers a number of advantages, including:

1. From a **technical** perspective:
 - 1.1. Reliability would be measured in terms of continuity of service to the supply points, which is arguably the right measure.
 - 1.2. Transmission companies would be free to expand their systems at their discretion and risk. This, arguably, would result in an efficient expansion.
2. From an **economic** perspective:
 - 2.1. If penalties for non-compliance with the standards are set properly by the regulator, the transmission company will have the right incentive to provide service with the desired level of reliability.
3. From a **regulatory** perspective:
 - 3.1. Regulation is much less intrusive and time consuming, and can be made to depend much less on information to be provided by the utility.
 - 3.2. Complementary regulation must be put in place regarding the treatment of system expansion costs. A number of approaches have been proposed and tried, notably those based on efficient systems⁸.

Moral

Power sector reform brings different specialists into one playground - engineers who enjoy operating sophisticated systems, economists who may be constantly thinking about market forces, and lawyers who are focused towards regulatory policies. Only if these specialists work together in designing suitable policies and institutions, a sustainable industry will emerge.

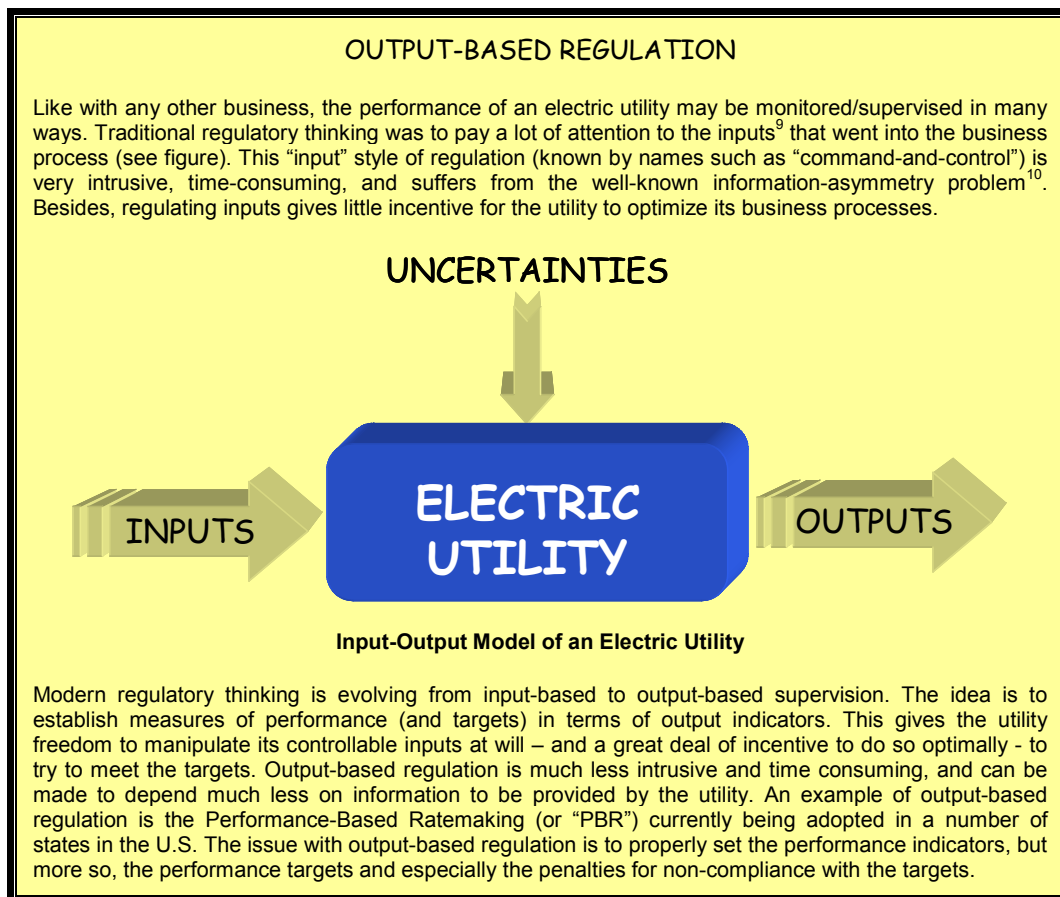


Figure 1

For further reading on the subject of reliability in this issue of the Siemens PTI eNewsletter, please see the article titled [Bulk Electric System Reliability](#) by Feng Dong and Baldwin Lam.

¹ The term n-1 refers to the normal system (with all “n” elements in service) minus “1” out.

² National Electric Reliability Council.

³ A mighty “force” (pun intended).

⁴ This is probably the only truly nondiscriminatory force at play in today’s power systems.

⁵ Merrill, H.M., and A.J. Wood, “A Busy Signal for Electric Power: A Day in the Life of N.U. Gigawatt,” *The Electricity Journal*, Vol. 3, No. 3, April, 1990.

⁶ Electrons do not flow, like many people claim. Instead, power systems exert a “force at a distance.”

⁷ Casazza, J., and F. Delea. “Understanding Electric Power Systems – An Overview of the Technology and the Marketplace,” IEEE Press, 2003.

⁸ Fischer, R., and P. Serra, “Regulating the Electricity Sector in Latin America,” *Serie Economía*, No. 86, August 2000, Universidad de Chile.

⁹ Examples of inputs are the CapEx, the number of employees, and the number of commercial offices. Examples of outputs are the amount of energy sold, the quality of service provided, and the outstanding receivables.

¹⁰ That is, the regulator will never be able to have access to the same amount and quality of information that is available to the utility it regulates.