2015 IEEE Power & Energy Society General Meeting

Impact of Power System Blackouts

M. M. Adibi, IEEE Life *Fellow, Nelson Martins, IEEE Fellow*

Panel Session at the IEEE PES GM 2015

"Cascading Failures: Advanced Methodologies, Restoration and Industry Perspectives"

Denver CO, July 2015

IEEE PES Power & Energy Society®

IEEE

On the magnitude and cost of blackouts

In the past decade, two significant declarations have been made that help define impacts of power system blackouts:

I- is on "The Magnitude Order of Blackout," and
II- is on "The Economic Cost of Blackout".

The former statement is in the US-CANADA Report of the August 14, 2003 Blackout, and

The latter statement is in several NERC Reports.

The Seven Major Disturbances, in the order of *Impact**

* U.S. – Canada 2003 Blackout Report

Location	Load	Customers	Duration	Scale
	P GW	C in 10^6	T in Hrs.	R=Log(P•C•T)
1. 2003 NE	**62**	**50**	**48**	**5.17**
2. 1965 NE	**20**	**30**	**13**	**3.89**
3. 1977 NYC	**6**	**9**	**26**	**3.15**
4. 1982 WSCC	**12.4**	**5**	**18**	**3.05**
5. 1996 WSCC	11.9	2	36	2.93
6. 1996 WSCC	28	7.5	9	2.93
FPL				1.8
7. 1998 M-west	0.95	0.152	19	0.44

"I. The Magnitude Order of Blackout"

The US-Canada Report on the August 14, 2003 Blackout cites seven past major power disturbances in the order of their greatest IMPACT.

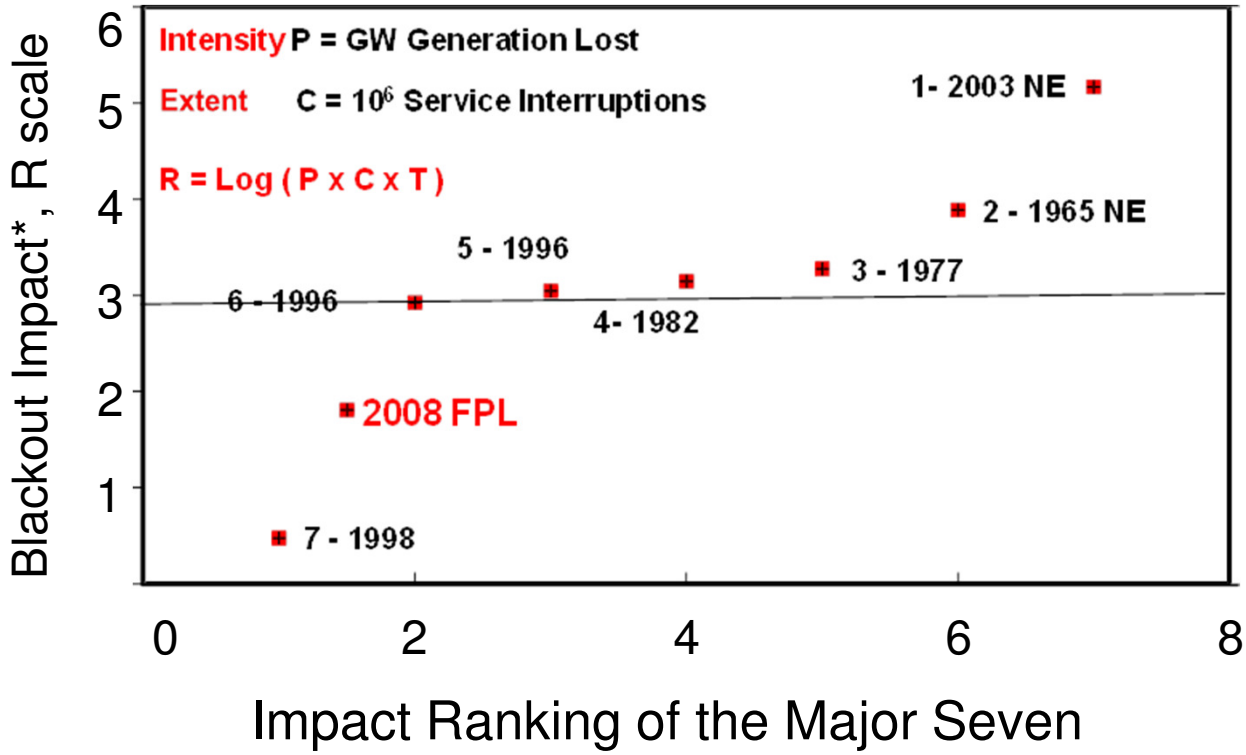
Apparently, in determining this order, product of intensity (P), extent (C) and duration (T) of the seven blackouts of the previous table are used.

Drawing parallel between R Scale = Log (P x C x T) and Richter Magnitude Scale, one finds that they are not dissimilar!

In fact in both definitions a single number has been sought to express the severity of event. Similarly, in both scales, R=3 appear to be the dividing value between moderate and sever earth quakes as well as blackouts!

For instance, the 2008 FPL blackout has a modest impact of R = 1.8, which shows it was not as severe as six of the blackouts listed in the table.

The Seven Major Disturbances



***U.S. – Canada 2003 Blackout Report -** It is noted that the data under **P: intensity** (load in GW), **C: extent** (number of customers in 10^6) and **T: duration** (in Hrs.), individually or in any combination, except as in **(P x C x T),** do not merit a 1 to 7 order of greatest impact.

IEEE PES Power & Energy Society®

IEEE

II. Economic Impacts of Blackouts

Direct Impacts of a Blackout

- Food spoilage
- Manufacturing plant shutdown
- Damage to electronic data and loss of computer services
- Loss of life support systems in hospitals, nursing homes, and households
- Suspension of electrified transport
- Traffic congestion due to the failure of traffic control devices
- Overtime wages for correctional personnel

II. Economic Impacts of Blackouts

Indirect Impacts of Blackouts

Long term

Litigation costs
Contamination due sewage disposal
Consequent increased disease

Short term

Property losses from looting and arson
Overtime payments to police & fire personnel
Cancellation of social

Medium term

Cost of recovering from looting
Lost tax revenues during recovery period
Consequent increase in insurance rate problems
Incarceration of looters

Economic Impact of a Blackout

(1977 NYC)

	Direct Cost ($M)	Indirect Cost ($M)
Business	34.0	160.4
Government	-------	12.5
Power Company	12.0	65.0
Insurance	------	33.5
Public health service	-------	1.5
Transportation	9.1	17.3
	=====	=====
Total	55.1	290.2**

**In 1977 Dollars

Economic Impact of a Blackout

NYC 1977 (26 Hours)

Direct cost	Indirect cost	Total cost	Unit
55.1	290.2	345.3	$\$x10^6$
Total Un-served MWH		101.4	GWH

a = 345.3 $\$x10^6$ b = 101.4 GWH

c = a / b = 345.3 / 101.4

c = $3.405x10^3$ \$/GWH

Cost of Un-served MWH: c = 3,405 \$/MWH

This cost is 100 times larger than the 1977 retail price of 34 \$/MWH

Economic Impact of a Blackout

Northeast 2003 (48 Hours)

Average retail price in 2003	= 93		$/MWH
Cost of unserved service is:	= 93 x 100=	9,300	$/MWH
Total unserved load:	920**		GWH

Total cost of the 2003 Blackout: 920** x 9,300= 8.6 x10^9 $

** North American Electric Reliability Council

Note: when assessing the economic impact of a blackout, the "direct" and "indirect" types of electric services and their costs need to be estimated

Power System Restoration Efforts

- In the aftermath of 1977 New York City blackout one of the requirements of DoE was for each one of the operating companies to develop a Power System Restoration plan, train the operating personnel in its use, and regularly update and maintain the plan.
- In response to this requirement, in 1978, the Power System Operation Committee established the Power System Restoration Task Force within the System Operation Subcommittee of the Power System Engineering Committee. Few years later the PSR TF was upgraded to the PSR WG.

PES Power System Restoration Efforts

- In August 1993 a 110 page brochure was prepared by PSR WG and published by the IEEE PES:

Publication IEEE`PES 93 TWO 605-6 PWR

Title: "Power System Restoration"

- Demand for the book was heavy, reflecting the wide interest in **PSR,** and the book was soon out of print.

PES Power System Restoration Efforts

- In June 2000, a 700 page book was prepared by PSRWG and published by Wiley-IEEE Press:

Power System Restoration

“Methodologies & Implementation Strategies”

ISBN 0-7803-5397- 8.

About the same time the industry went through restructuring, losing interest in restoration in favor of economy of operation.

Power System Restoration Efforts

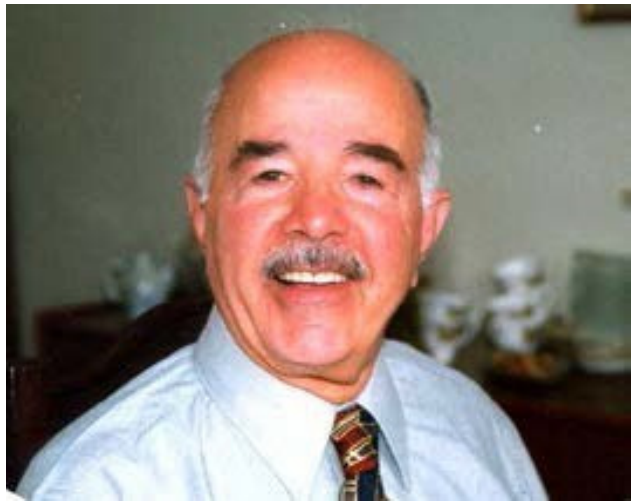
Following the 2003 Northeast and Canada blackout, once again there was much interest in PSR. Therefore a 343-page book was prepared by the RD TF, and published by PES Resource Center:

Technical Paper Compendium - Power System Restoration Dynamics (Issues, Restoration Techniques, Planning, Training & Special Considerations) PES-TPC1, July 07/2014

The compendium is compiled from 40 IEEE papers by 110 authors including the 42 panelists of the Restoration Dynamics Task force (RD TF). Discussions by the panelists and a Closure by the authors have been added. The compendium covers: real power balance and control of frequency, reactive power balance and control of voltages, the critical tasks (time sensitive functions), analyses and simulations.

Mike's Reminder

"As blackouts do happen, always keep your power system restoration updated!"



Thank You!