IEA Experts' Group on R&D Priority Setting and Evaluation (EGRD)



Italian strategy towards Power System Resilience and Regulatory scenario

Emanuele Ciapessoni Ricerca sul Sistema Energetico - RSE S.p.A. <u>emanuele.ciapessoni@rse-web.it</u>

13 - 14 May 2019

Outline



- The context : managing modern/future power systems
- What's resilience?
 Reliability, security and resilience
- A risk based approach for power system management
- Regulatory scenario
- Conclusions

Italian strategy towards Power System Resilience and Regulatory scenario



ETIP SNET THREE GOALS OF EU ENERGY POLICY PLAN INNOVATE FRIDAS Secure, resilient, reliable supply Systems integration Reduce imports dependence Resilience & reliability Affordable Market integration and market- Long-term investment signals Climate change mitigation based energy Prosumers at Protected the centre Pollution reduction services Circular economy environment

ETIP SNET – Vision 2050





PS Criticalities

PS is a Continent-wide very complex interconnected synchronous network

Disturbances originated in an area may propagate throughout the interconnection, leading to significant loss of service (blackouts)

PS is *increasingly vulnerable* to different threats, with significant *cascading impact*

- on the surroundings (environmental, economical etc) and
- on the overall society (security of supply etc).

This trend is expected to continue in the future, especially in the perspective of *SmartGrids* (ICT vulnerabilities & failures)

Smart Grids deployement increases the needs of *security* and *resilience* of ICTs. Natural and man induced events and phenomena cannot be fully controlled



Infrastructure damages due to external events





Why *Resilience*





ARERA 645/2017/R/EEL September 21, 2017

SIGNIFICANT EVENTS

- Blackout (> 8 ours) in Emilia Romagna and Lombardia (February 2015), involving **360.000 customers**
- Backout (> 72 ours) In Abruzzo and Marche (January 2017) involving 39.000 customers

Why *Resilience*



RSF

Sistema

Interruptions duration of LV users caused by MAJOR FORCE events [ARERA 2 DCO 645/17]



9

MANAGEMENT OF MODERN/FUTURE POWER SYSTEMS

Management of modern/future Power Systems

RSE



Many sources of uncertainty ...









WHAT'S RESILIENCE? RELIABILITY, SECURITY AND RESILIENCE



State and resilience





Why resilience?

RSE Ricerca Sistema Energetico

What's a reliable power system in case of extreme events?

- Traditionally ...
 Reliable = Secure + Adequate
- Security criteria require PS keeps the electricity supply to customers intact in case of N-1 contigencies

 Can a Power System be secure to extreme events?
 NO!

Due to excessive costs for system management

Instead of N-k security

• We can require that *system degradation is limited* in case of *extraordinary events*

Resilience is born!

What's resilience?



Definition from Cigré WG C4.47

FINAL

Definition – Power System Resilience

- **Power system Resilience** is the ability to limit the extent, severity and duration of system degradation following an extreme event.
- This is achieved through a set of *key actionable measures* to be *taken* before, during and after extreme events, such as:
 - anticipation,
 - preparation,
 - absorption,
 - adaptation,

cigré

- rapid recovery and
- sustainment of critical system operation
- including application of lessons learnt.

C4.47 – Power System Resilience Working Group

Resilience refers to PS response to extreme events

Cigré WG C4.47 addresses these topics:

- 1. What are <u>current efforts</u> being conducted to protect critical infrastructure?
- 2. <u>Definition of power system resilience</u> in electricity sector?

3. What is the **appropriate approach and methodology** to be followed **for analyzing** power systems **resilience**?

4. What **metrics** should be used **to quantify** the **resilience** performance of a power grid in the face of a disaster (*High-impact, Low-probability event*)?

5. How do we <u>decide on and plan investment</u> portfolios for boosting resilience?

6. How should we define the <u>critical</u> <u>infrastructure</u> and the <u>interdependencies</u> between critical infrastructures?

7. <u>Policy and regulatory framework</u> to create the environment to encourage the adoption of prudent decision making?



What's resilience?



Definition from Cigré WG C4.47

FINAL

Definition – Power System Resilience

- **Power system Resilience** is the ability to limit the extent, severity and duration of system degradation following an extreme event.
- This is achieved through a set of *key actionable measures* to be *taken* before, during and after extreme events, such as:
 - anticipation,
 - preparation,
 - absorption,
 - adaptation,

cigré

- rapid recovery and
- sustainment of critical system operation
- including application of lessons learnt.



C4.47 – Power System Resilience Working Group

Resilience refers to PS response to extreme events

Approach

- Separation between the «property» and the «key measures» which make a system resilient
- ✓ Reference to degraded
 performance and extreme
 event, i.e to HILP (High
 Impact Low Probability)
 event
- ✓ Precise characterization of degradation, by means of «extent», «severity» and «duration»



A RISK BASED APPROACH FOR POWER SYSTEM RESILIENCE THE RSE ITALIAN PERSPECT



Fundamental skills RSE to manage resilience **Power system Environment** management Grid infrastructure

Threats affecting Power Systems



Main causes of damages due to natural events:

- 1. Wind storms
- 2. Ice/snow storms
- 3. Lightning
- 4. ...



Vulnerability of ICT/Power Systems



21

ICT/Power systems are vulnerable to both natural and human related threats



Power component threats	External (Exogenous)	<i>Internal</i> (Endogenous)
Natural	Lightning, fires, ice/snow storms, floods, solar storms	Component faults, strained operating conditions
Man-related (unintention al or deliberate)	Unintentional damage by operating a crane; Sabotage, terrorism, outsider errors	Employee errors Malicious actions by unfaithful employees

FROMSecurityTOVulnerability/RiskFORResilience

N-1 security against a credible set of contingencies RESILIENCE to events of substantial risk

Vulnerability/Risk analysis

The **BOW TIE** model



Focus

- Multiple contingencies (functional and geographic dependencies)
- ICT dependencies
- Cascading

The methodology is based on an extended concept of «RISK»

RISK = {threat, vulnerability, contingency, impact}

Countermeasure assessment

a sensitivity-based approach





RSE for *Resilience Some RSE tools*



Visualizzazione georeferenziata dei componenti critici di rete!



ISAP tool Valutazione degli indicatori di resilienza sulla rete di trasmissione



The method is not limited

to wet snow events ...



Effect of different Threat Scenarios on

System Risk/Resilience



RSE very active in resilience!

- CIGRE C4.47 WG «Power System Resilience»
- IEEE WG on «Cascading outage»
- CIRED WG on the «Resilience of distribution networks »
- **TERNA** in using the monitoring and forecasting tools **WOLF/WILD**
- RSE take part in the ARERA task forces on natural threats and system restoration
- RSE take part in thr **ARERA** resilience technical table

.... And there is still a long way to go!



Current efforts to enhance resilience in Italy



- RSE collaborated in the CEI (Italian Electrotechnical Committee) working group on resilience and several stakeholders, like the main DSO's and the Italian TSO.
- The aim of the working group was to set the guidelines for a methodology to define and compute resilience metrics in case of weather events and to evaluate resilience benefits from enhancements in grid infrstructure or operation
- These guidelines are being used to define the integrated defense plan (PID) to enhance transmission and distribution system resilience
- Chosen indicator was the inverse risk of customer disconnection (RT/#NSU).



Regulatory framework to resilience in Italy



29

- ARERA (Italian NRA) established a «Resilience table» inviting stakeholders, CEI and RSE to define a methodology for resilience assessment and enhancement starting form the results of CEI WG
- A consultation was performed by ARERA to establish the framework for resilience evaluation, accounting and enhancement
- The indicator identified by CEI WG was enforced
- Different kind of incentives was be investigated. A TOTEX approach was established.

Regulatory framework to resilience in Italy (2)



30

presented «*resilience enhancement* with cost benefit analysis.

work is on going

Some further references **N RSE**

Journals/Conferences

- E. Ciapessoni, D. Cirio, G. Kjølle, S. Massucco, A. Pitto and M. Sforna, "Probabilistic Risk-Based Security Assessment of Power Systems Considering Incumbent Threats and Uncertainties", IEEE Trans. on Smart Grid, vol. 7, no. 6, pp. 2890-2903, Nov. 2016.
- E. Ciapessoni, D. Cirio, A. Pitto, P. Marcacci, M. Lacavalla, S. Massucco, F. Silvestro, M. Sforna, "A Risk-Based Methodology and Tool Combining Threat Analysis and Power System Security Assessment", *Energies 2017*, Vol 10, no. 4, pp.1-16.
- E. Ciapessoni, D. Cirio, A. Pitto and M. Sforna, "A probabilistic risk-based security assessment tool allowing contingency forecasting", 2018 IEEE International Conference on Probabilistic Methods Applied to Power Systems (PMAPS), Boise, ID, 2018, pp. 1-6.
- P. Bonelli, M. Lacavalla, P. Marcacci, G. Mariani, and G. Stella, "Wet snow hazard for power lines: a forecast and alert system applied in Italy", *Nat. Hazards Earth Syst. Sci.*, 11, pp. 2419-2431, 2011.
- M. Lacavalla, P. Marcacci, A. Freddo, "Wet-snow activity research in Italy", IWAIS 2015, Uppsala Sweden.
- M. Lacavalla, P. Marcacci, C. Chemelli, M. Balordi, R. Bonanno and G. Pirovano "Operational Forecast and Research Activities on Wet snow Accretion in Italy", Proceedings IWAIS 2017, 2017.
- IEC 60826/Ed4 (2017) " Design Criteria of Overhead Transmission Lines".
- M. L. Pestana et al. (RSE author: C. Carlini) "Resilience of Distribution Grids", CIRED WG report, May 31, 2018.
- G. Viganò, C. Carlini et al. "The control of active distribution networks: The experience of the Italian 'demo' of the European project GRID4EU", January 2016, Energia Elettrica, Vol. 93, no. 4, pp. 39-49.

Report

• E. Ciapessoni, A. Pitto, "Analysis of the resilience of the Italian power system with respect to the phenomenon of ice sleeves and assessment of control actions", RSE, Report RdS 18000395, Feb 2018.

Take away messages



32

- Resilience and Risk are fundamental concepts for operating modern power systems
- In Italy a Probabilistic risk based method is used in planning for resilience according to ARERA deliberations
- Risk methods for operation are still quite far from being deployed in control centers, currently wether forecast is used by TSO and will be used by DSOs.
- Future methods and tools will support operators by suggesting the most suitable countermeasures (passive and active) for different threats over different time scales (from planning to operation)

Resilience based **Nagement** o recuce risk of

Italian strategy towards Power System Resilience and Regulatory scenario





emanuele.ciapessoni@rse-web.it

