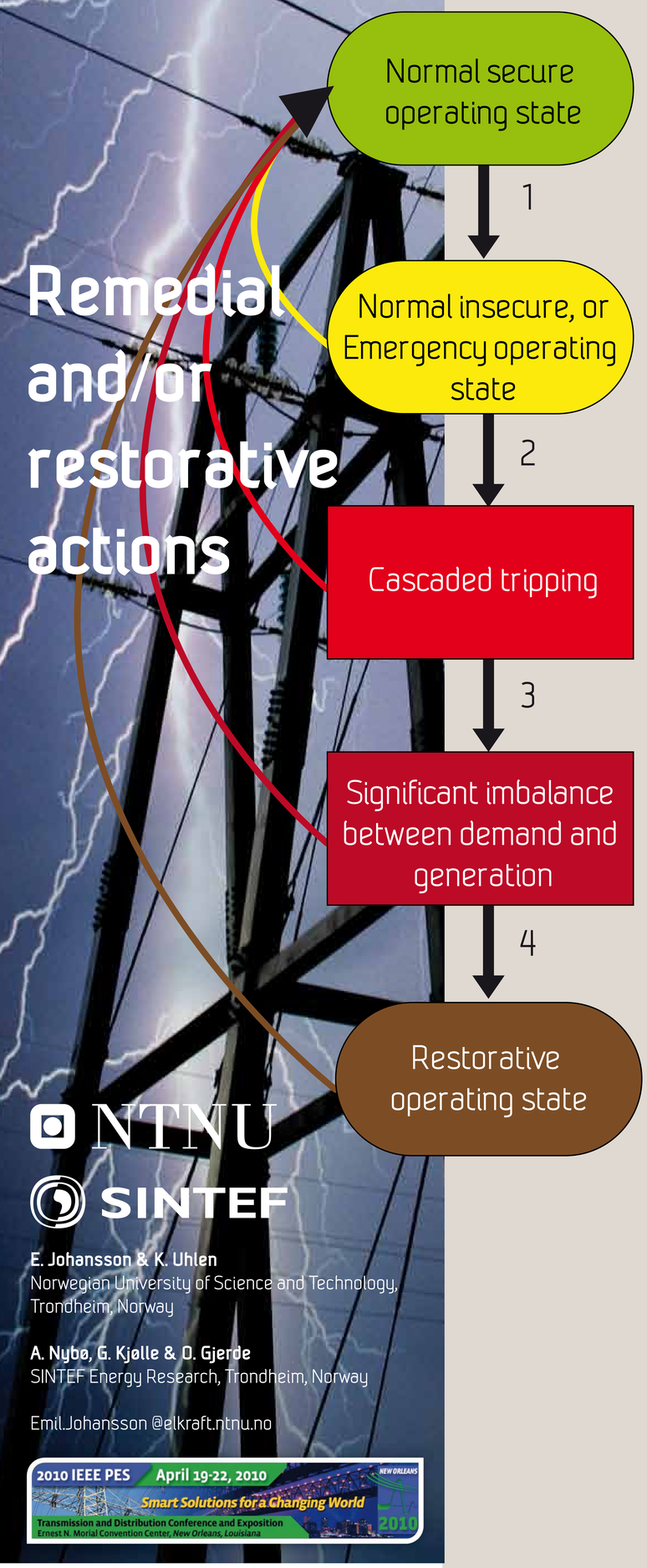
BLACKOUT

Understanding Sequence, Causes, & Remedies of **Extraordinary Events**



NTNU
SINTEF

E. Johansson & K. Uhlen
Norwegian University of Science and Technology, Trondheim, Norway

A. Nybø, G. Kjølle & O. Gjerde
SINTEF Energy Research, Trondheim, Norway

Emil.Johansson @elkraft.ntnu.no

2010 IEEE PES April 19-22, 2010 NEW ORLEANS
Smart Solutions for a Changing World
Transmission and Distribution Conference and Exposition
Ernest N. Morial Convention Center, New Orleans, Louisiana
2010

Increased understanding of extraordinary events in the electrical power system is vital in order to develop and assign appropriate remedies to limit the presence and consequences of such extraordinary events in the future.

Sequence of Events

Extraordinary events varies widely. Analyses of events show similarities, and a generalised sequence can be described as:

1 An uncomplicated fault triggers the event, shifting the operating state to insecure or emergency.

2 Insufficient remedial actions is followed by fast cascaded tripping.

3 The system separates into islands with significant imbalance between demand and generation.

4 Inadequate control lead to blackout of the power system.

Root Causes

The root cause is the most fundamental aspect of the cause of an event. If corrected it would prevent the recurrence of similar events, why the identification of true root causes is highly important.

Generally, root causes are related to system operation, and some identified root causes involved in recent extraordinary events are:

- Lack of situational awareness
- Inadequate islanding schemes and other defence plans
- Inadequate system understanding
- Inadequate emergency procedures
- Inadequate system planning and operating criteria

Potential Remedies

Wide area monitoring systems
An enhanced monitoring system could be used to improve the situational awareness to increase the time available for manual intervention of extraordinary events.

Controlled islanding schemes
Successful island operation could constitute the difference between system blackout and limited load shedding. Improvement of controlled islanding schemes seems promising in order to limit disturbance propagation and consequence of extraordinary events.

Further work

The proposed generalised description of extraordinary events will be analysed further providing input to the development of countermeasures to reduce the risk of extraordinary events, in terms of enhanced monitoring, protection and control systems. The work will emphasise on system protection schemes and wide area monitoring systems to decrease the vulnerability to extraordinary events.