National Research Council

The Initial Sources of Power

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The *impact* of a blackout

exponentially increases with the duration of the blackout,

and

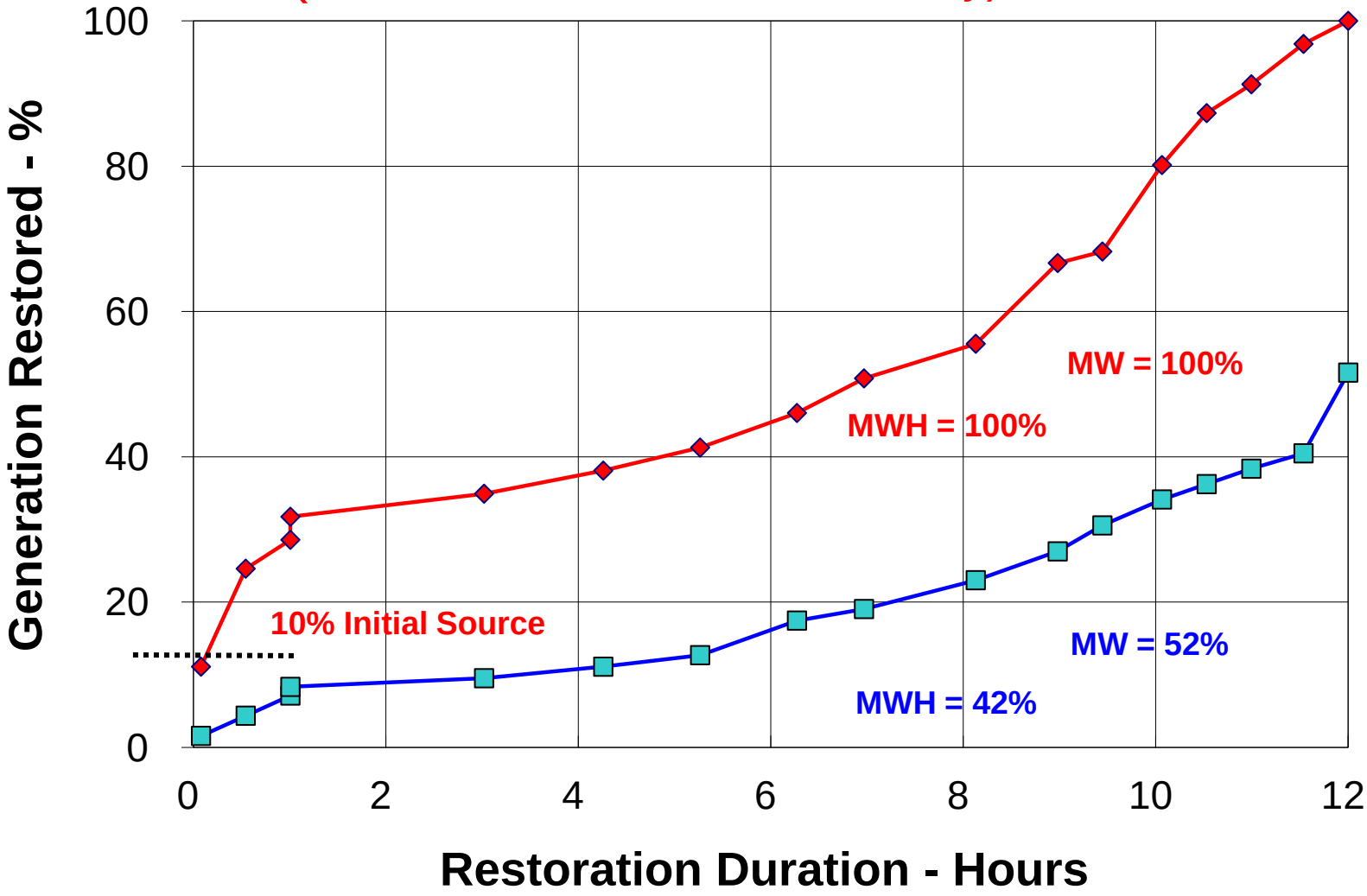
the duration of restoration

exponentially decreases with the availability of

The Initial Sources of Power.

The Significance of the Initial Source

(Based on Generation availability)



Initial and Critical Loads

(Several Time Sensitive Loads)

- Cranking Drum-Type Units
  Hot Startup to Cold Startup
- Pipe-Type HPOF Cables Pumping System
  Loss of Oil Pressure & Insulation Integrity
- Transmission Stations
  Loss of Stored Energy, Batteries & Gas (SF6)
- Distribution Stations
  Supplying Trans. Station & other Critical Loads
- Cold Load Pickup
  Doubling or More in Half an Hour
- Industrial Loads
  Al Pots, Cu , Fe, Batch Processes)

The Initial Sources of Power Attributes:

Size: Active & reactive power capabilities*

Availability: The hot and cold startup timings

Reliability: Probability of the 1st startup & elapsed time to the 2nd attempt

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*Adequacy of under excitation for remote blackstart

The Initial Sources of Power are provided:

1. Automatically by protection and control, in seconds to a minute

and

2. Manually by power plant and power system operators in tens of minutes to an hour

The Initial Sources of Power

Are automatically provided by (1) :

- Full load rejection (2)
- Low frequency isolation scheme (3)
- Controlled separation (3)

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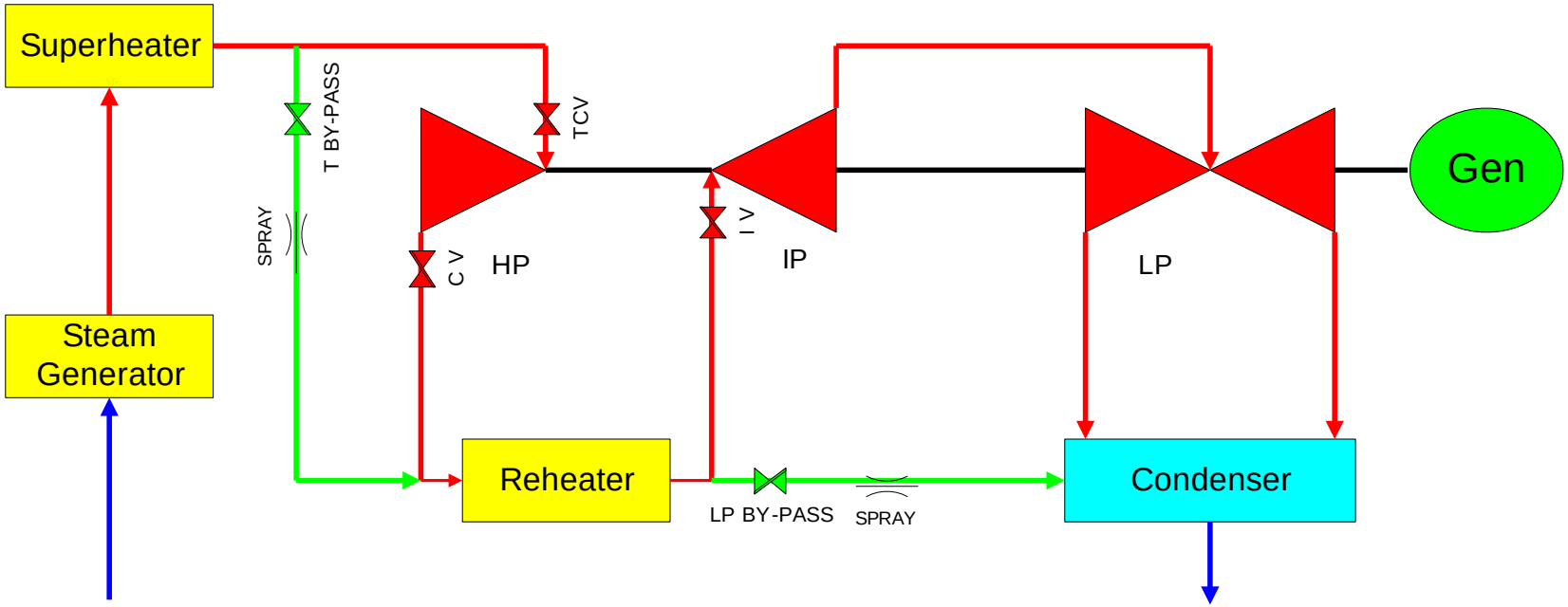
(1) The UFLS is coordinated with all the three measures

(2) Independent of power system, included in NERC's Definition

(3) Dependent on power system, excluded in the NERC's Definition

Basic System for Load Rejection

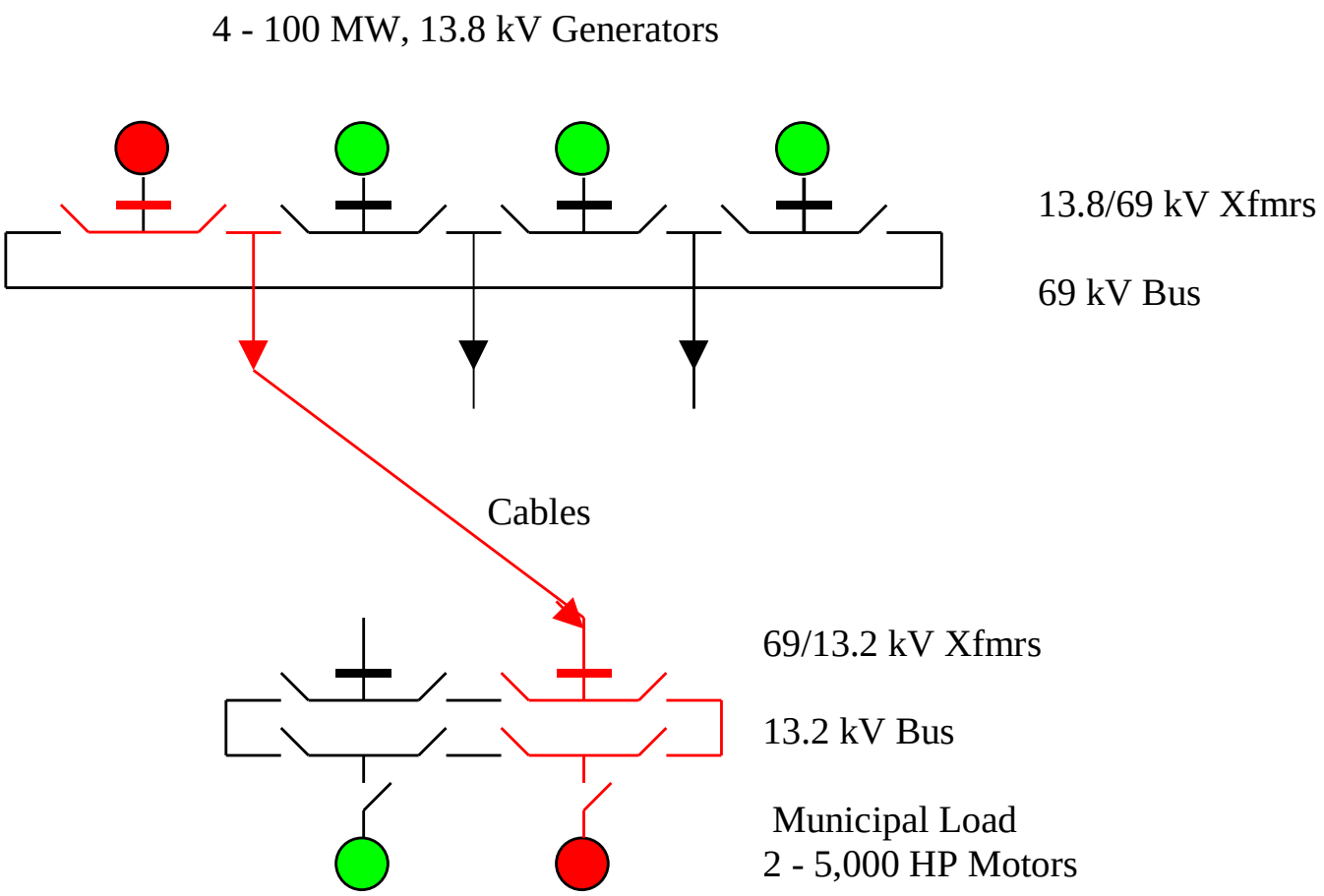
(Boiler:10^6 pph, >3,000 psi, >10^3 ˚F, ~ 125 MW)



TCV: Turbine Control Valve,
IV : Intercept Valve,
CV : Check Valve

Low Frequency Isolation Scheme

After the Initial Event



Controlled Separation (Islanding)

Internal & External Faults:

1. Practically all transmission lines are protected against internal faults by some types of distance relays.
2. Most of the internal faults are cleared leaving the power system in an un-faulted condition.
3. Only a limited number of internal faults may cause external faults due to out-of-step relay operations.

Controlled Separation (Islanding)

Out-of-step blocking relays:

- Prevent separation where there is heavy power flow (unbalanced load and generation).

Transfer tripping relays:

- Allow separation where there are light power flows (balanced load and generation).

Initial Sources of Power

Operator Initiated

	Startup	
• Run-of-the-River Hydro	5-10	min
• Pump-Storage Hydro	5-10	min
• Combustion Turbine (Cold) (1)	5-15	min
• Combustion Turbine (Hot)	2	Hrs.
• Drum Type Steam (Hot)	45	min
• Drum Type Steam (Cold)	3	Hrs.
• Super Critical Once Thro	8	Hrs.
• Nuclear Units	24+	Hrs.

(1) Probability of success (one in two or three) 30 to 50%

Automatic Vs. Manual

Experience:

The probability of success in retaining initial sources of power has been:

> 50% for automatic (1) , and

< 50% for manual (2).

Challenge:

The need for better Protection and Control coordination between:

- The electrical system, and
- The prime movers (3)

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(1) Relatively few operational, due to conservative operating philosophy.

(2) Rely on two or more combustion turbines due to startup failure.

(3) One order of magnitude difference in responses.

Protection & Control Issues

Conservative Operating Philosophy?

Relay performance is measured By:

1. Correct and Appropriate Operations
2. Correct and Inappropriate Operations
3. Wrong Tripping Operations
4. Failure to Trip

The primary reasons for the (2) & (4) are the significant changes in the power system topology and operation.

During restoration the power system undergoes continual changes and therefore it is subject to (2) & (4).

Blackstart Resource

NERC Definition

A generating unit(s) and its associated set of equipment which has the ability to be started without support from the System(1) or is designed to remain energized without connection to the remainder of the System(2), with the ability to energize a bus, meeting the Transmission Operator's(3) restoration plan needs for real and reactive power capability, frequency and voltage control, and that has been included in the Transmission Operator's (3)restoration plan.

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(1) Includes Load Rejection.

(2) Excludes Load Frequency Isolation Scheme and Control Separation.

It does not cover the availability and reliability requirements.

(3) Places burden of adequate Blackstart Resource on the shoulders of Transmission Operator.