Standby Generators for Business Continuity

December 13, 2016

Meet Your Presenters:

Mike Carter

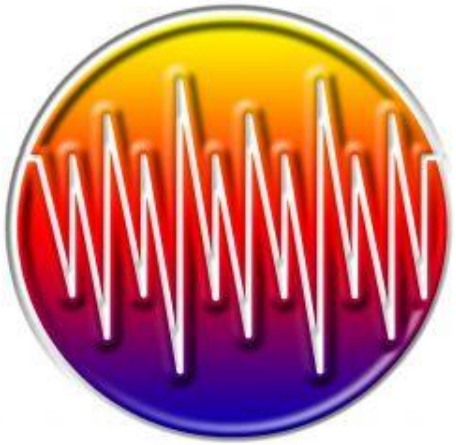
Content

- Reliability Cost
- Backup Power Options
  - Generators
  - Uninterruptible Power Supplies
- Equipment and Personnel Protection
- Codes and Standards
- Generator Tips

Source: NOAA

Reliability Cost

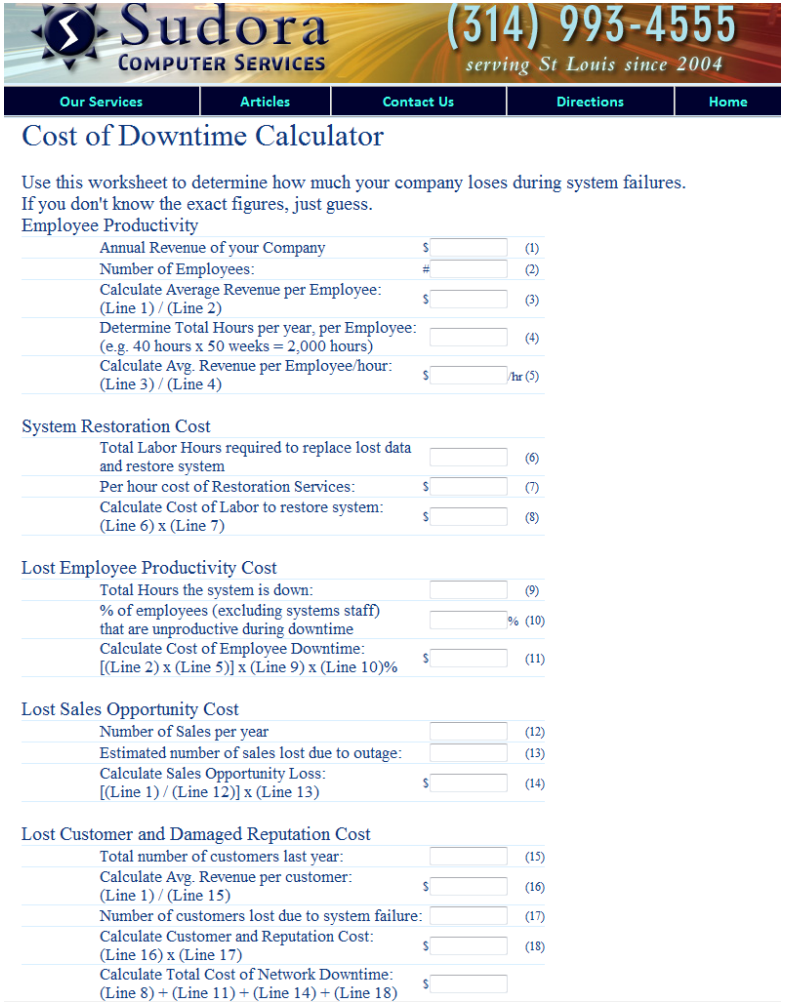
- Quantify
  - Financial impact of power reliability
    - Duration of events
    - Frequency of occurrence
    - Timing of when events occur
    - Amount of advance notice that a facility receives



Source: Stock.xchng

Reliability Cost

- Cost of downtime
  - Employee productivity
  - System restoration cost
  - Lost sales opportunity cost
  - Lost customer and damaged reputation cost



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Cost of Downtime Calculator

Use this worksheet to determine how much your company loses during system failures.
If you don't know the exact figures, just guess.

Employee Productivity

Annual Revenue of your Company	$	(1)
Number of Employees:	#	(2)
Calculate Average Revenue per Employee: (Line 1) / (Line 2)	$	(3)
Determine Total Hours per year, per Employee: (e.g. 40 hours x 50 weeks = 2,000 hours)		(4)
Calculate Avg. Revenue per Employee/hour: (Line 3) / (Line 4)	$ /hr	(5)

System Restoration Cost

Total Labor Hours required to replace lost data and restore system		(6)
Per hour cost of Restoration Services:	$	(7)
Calculate Cost of Labor to restore system: (Line 6) x (Line 7)	$	(8)

Lost Employee Productivity Cost

Total Hours the system is down:		(9)
% of employees (excluding systems staff) that are unproductive during downtime	%	(10)
Calculate Cost of Employee Downtime: [(Line 2) x (Line 5)] x (Line 9) x (Line 10)%	$	(11)

Lost Sales Opportunity Cost

Number of Sales per year		(12)
Estimated number of sales lost due to outage:		(13)
Calculate Sales Opportunity Loss: [(Line 1) / (Line 12)] x (Line 13)	$	(14)

Lost Customer and Damaged Reputation Cost

Total number of customers last year:		(15)
Calculate Avg. Revenue per customer: (Line 1) / (Line 15)	$	(16)
Number of customers lost due to system failure:		(17)
Calculate Customer and Reputation Cost: (Line 16) x (Line 17)	$	(18)
Calculate Total Cost of Network Downtime: (Line 8) + (Line 11) + (Line 14) + (Line 18)	$	

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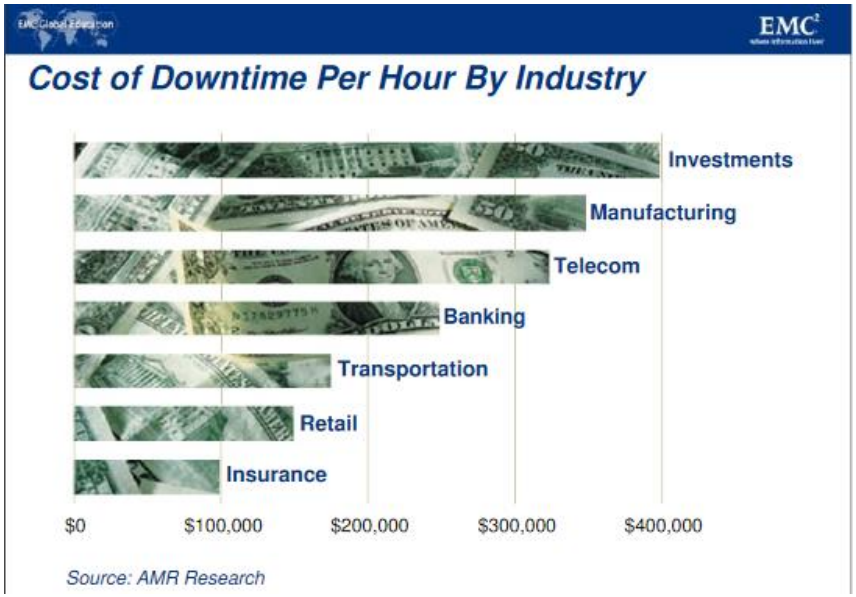
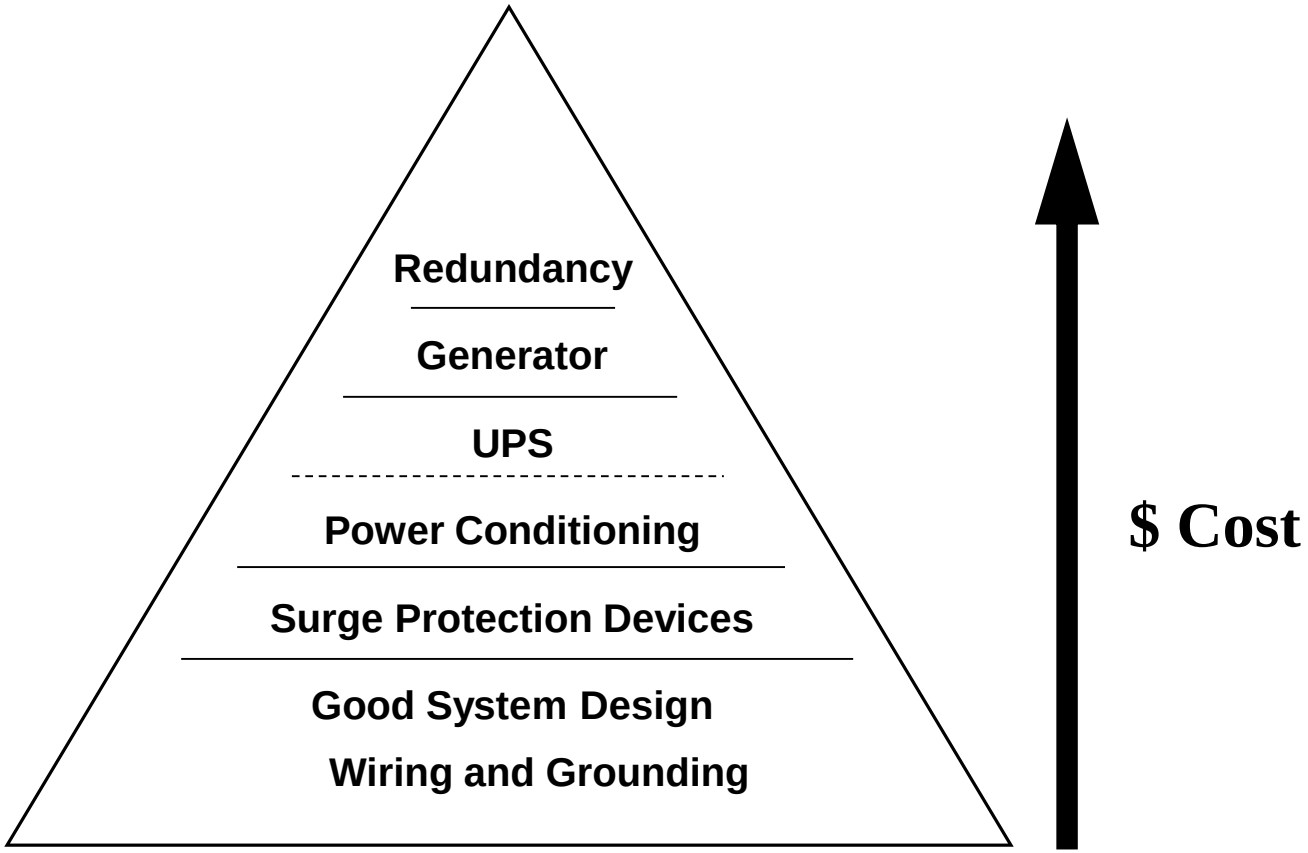
Reliability Cost

- Cost of downtime
  - Business segment
    - IT industry average of $5,600 per minute or $340,000 per hour (Ponemon Institute study)



Backup Power Options



Source: Liebert Corporation

Backup Power Options

- Backup Generators
  - Capital costs

Capital Costs, $/kW			
Diesel	Natural Gas	Micro-turbine	Fuel Cell
$150-$250	$200-$300	$1,000	$3,000-$4,000

  - Installation costs
    - Roughly 50% of the purchase cost
      - Can approach $10,000 for a 100 kW unit
    - Small installation cost penalty for oversizing
  - Maintenance costs
    - $500 to $1,000 per year
    - $20,000+ for major overhaul
    - Diesels considered most mechanically reliable

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Backup Power Options

- Backup Generator Fuel Use
  - Operating cost of $0.08 to $0.18/kWh range
    - Be sure to include electric demand charges for comparison
  - Diesel and oil costs 2X more than natural gas

Generator Estimated Fuel Use (75% load)				
		Standby Rated kW		
Fuel	Units	200 kW	500 kW	1,500 kW
Diesel/ #2 Fuel Oil	Gallons/hr	11	27	85
Natural Gas	CCF/hr	18	43	123

Source: Detroit Diesel & Caterpillar

Poll Question

- How long have you had backup generators at your facility?
  a) More than 5 years
  b) Between 1 and 5 years
  c) < 1 year
  d) We presently have no backup generators.

Backup Power Options

- Backup Generator Fuel Sources
  - Natural Gas Advantages:
    - Lowest cost fuel
    - Unlimited fuel source—refueling not necessary
    - Cleaner burning
    - Available during power outages
    - No storage facilities required
  - Natural Gas Disadvantages:
    - Efficiency decreases 15% to 25% at half-load conditions
    - May be unavailable during natural disasters (earthquake, hurricane, and so on)
    - Fuel system plumbing increases installation costs

Source: DOE ARPA

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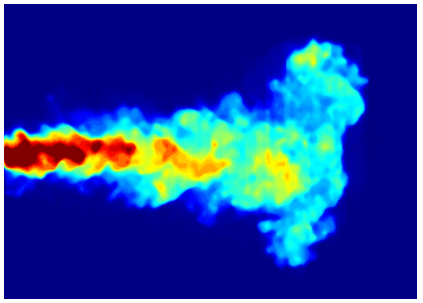
Backup Power Options

- Backup Generator Fuel Sources
  - Diesel/Oil Advantages:
    - Efficiency curve for diesel engines is comparatively flat
    - Easily obtained
    - Onsite fuel delivery available
    - Portable
  - Diesel/Oil Disadvantages:
    - 12- to 18-month shelf life
    - Installing large storage tanks increases costs
    - May not be available during power outages
    - Wet stacking
    - Harder to start in cold weather
    - NOx and particulate matter emissions



Source: Sandia Nat'l Lab

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Backup Power Options

- Backup Generator Fuel Sources
  - Propane Advantages:
    - Long shelf life
    - Clean burning
    - Easily stored in both large tanks or in smaller, 5 to 10 gallon cylinders
    - Obtainable during a power outage—fuel stations may be unable to pump fuel during an area-wide outage
  - Propane Disadvantages:
    - Pressurized cylinder of flammable gas
    - Fuel system is more complicated—increased possibility of failure
    - Larger tanks are not aesthetically pleasing (unsightly)

Source: State of Nebraska

Backup Power Options

- Generator Codes and Standards
  - ANSI/IEEE Standard 446, Emergency and Standby Power Systems
  - NFPA 70 National Electrical Code, Articles 700, 701, 702, 708
  - NFPA 99/NEC 517 Health Care Facilities
  - NFPA 101 Life Safety Code
  - NFPA 110, Standard for Emergency and Standby Power Systems
  - UL 1008 Automatic Transfer Switches

Backup Power Options

- Emergency vs Standby Generators
  - Emergency system (NEC Article 700)
    - Responds to power failure
    - Legally required
    - Intended to supply, distribute, and control power and illumination essential for safety to human life
      - Help you leave the building
  - Standby power system
    - Legally required standby system (NEC Article 701)
    - Optional standby system (NEC Article 702)
    - Critical operations power systems (NEC Article 708)

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Poll Question

- Which of the following is NOT an advantage of natural gas as a backup generator fuel?
  - a) Emissions
  - b) Fuel storage
  - c) Installation cost
  - d) Operating cost
  - e) Available during power outage

Backup Power Options

- Emergency Generator (NEC Article 700)
  - 10 second response
  - No diversity demand factors
  - Separate wiring circuits
  - Overcurrent protection selective coordination
  - Ground fault alarms
  - Acceptance/operational testing required under maximum anticipated load
  - Minimum 2-hour fuel supply
  - Automatic transfer switch (ATS) required

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Backup Power Options

- Emergency System Operating Restrictions
  - No limit on operation during normal utility outages
  - Federal
    - 100 hour limit for maintenance and testing
    - 50 hour limit for non-emergency situations
    - 15 hour limit for “emergency” demand response has been revoked as of May 1, 2016
    - No peak shaving
  - New Jersey
    - Emergency, maintenance, and testing operations only
    - Maintenance and testing not during days forecasted to have poor air quality.
    - Cannot participate in economic demand response programs.

Backup Power Options

- Standby Power System (NEC 701, 702, 708)
  - Response time
    - 60 seconds for legally required
    - No requirement for optional standby
    - “Time required” for critical operations power systems (COPS)
  - Demand diversity factors allowed
  - Combined circuits
  - Acceptance/operational testing required under load

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Backup Power Options

- Standby Power System (NEC 701, 702, 708)
  - Ground fault response
    - Alarm for legally required
    - Protection for optional standby and critical operations power systems (COPS)
  - Minimum fuel supply
    - 2 hours for legally required
    - No requirement for optional standby
    - 72 hours for COPS
  - Manual transfer switch acceptable for optional standby
    - Automatic transfer switch for COPS

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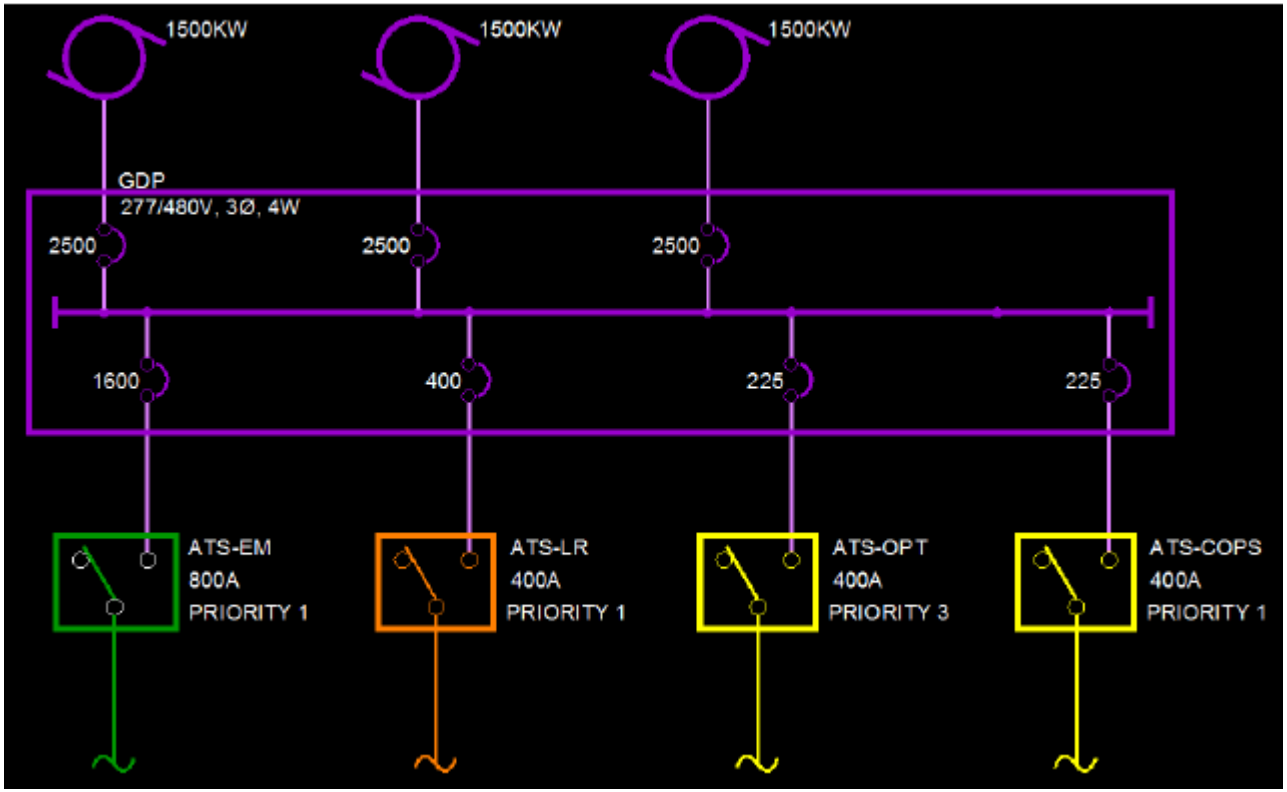
Backup Power Options

- Commercial Building with Critical Operations Power Systems (COPS)



Emergency | Legally Required | Optional | COPS

Source: TLC Engineering for Architecture

Backup Power Options

Requirement	Emergency	Legally Required Standby	Optional Standby	COPS
Minimum Fuel	2-hour	2-hour	Any	72-hour
Start Time	10 seconds	60 seconds	Any	Time required
Demand Factor	None – full load	None – full load	Allowed	None – full load
Selective Coordination	Full	Full	None	Full
Testing	Acceptance/ Operational Max Load	Acceptance/ Operational Under Load	None	Commissioning Under Load
Circuits	Isolated	Can combine	Any	Can combine
Fault Response	Alarm	Alarm	Protection	Protection
Transfer Switch	Automatic	Auto/Manual	Any	Automatic

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Uninterruptible Power Supplies

- UPS Systems
  - Three types
    - Online or *true* UPS (double conversion)
    - Offline UPS (standby battery and inverter)
    - Hybrid or line-interactive or direct ferroresonant transformer UPS
  - Energy Storage (≈50% of system cost)
    - Lead Acid Batteries
    - Flywheels
    - Ultra-capacitors
  - UPS cost
    - $300 to $2,000 per KVA
      - 5 KVA for doctor's office is $1,500 to $2,000
      - 10-20 kW for retail chain is $15,000 to $20,000
      - 1 MW for data center is $400,000 plus $200,000 installation
    - Flywheel is 50% more

Source: LBNL

Uninterruptible Power Supplies

- UPS Suppliers
  - Big Three
    - APC/Schneider
    - Liebert/Emerson
    - Powerware/Eaton
  - Others include Emerson/Chloride/ONEAC, Mitsubishi, and General Electric
- Energy Efficiency of UPS
  - Depends on load
  - Redundant systems reduce load on each UPS
  - Rightsizing can reduce power costs 75% over 10 years

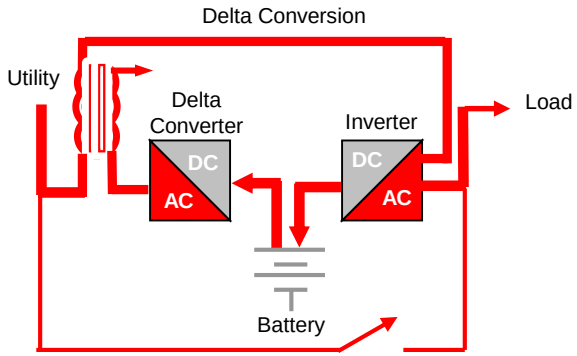
Avg. Load	UPS Efficiency
100%	93%-97%
30%	89%
10%	50%

Poll Question

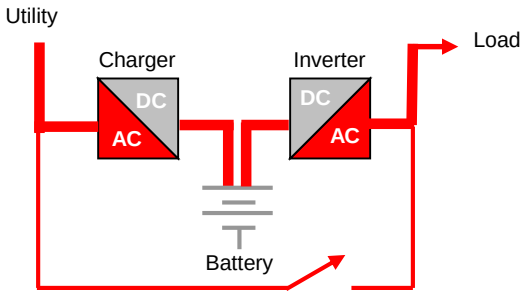
- Which of the following is NOT an NEC requirement for emergency generators?
  a) 10-second start-up response time
  b) Separate wiring circuit
  c) Ground fault protection
  d) Testing under maximum load
  e) Minimum 2-hour fuel supply

Uninterruptible Power Supplies

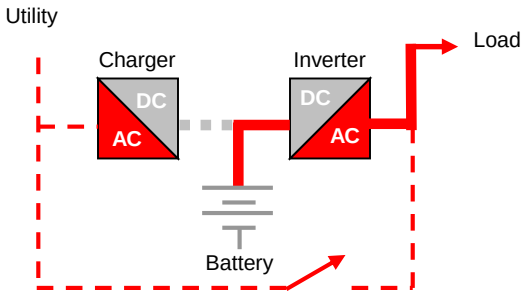
- Uninterruptible Power Supply (UPS)
  - Online UPS (double conversion or true online)
    - *Continuously* powers the load
    - No switchover time
    - Best power conditioning
    - Best waveform
    - Delta converter more efficient than double conversion



Delta Conversion



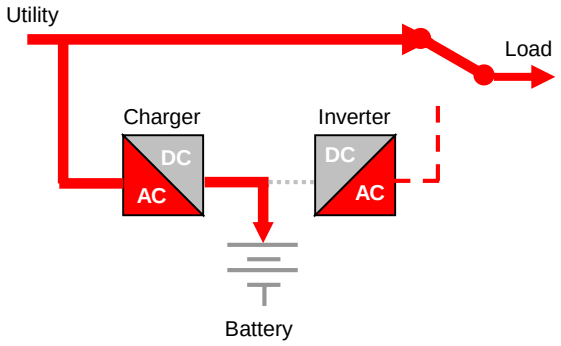
Standard Operation



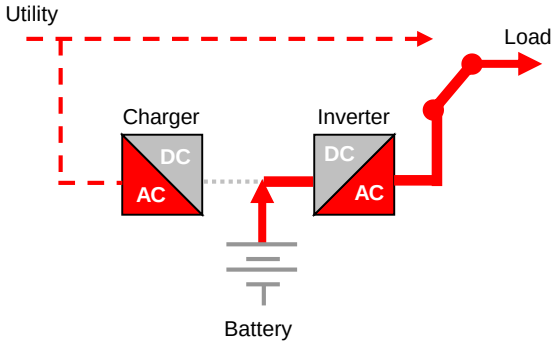
Power Interruption

Uninterruptible Power Supplies

- Uninterruptible Power Supply (UPS)
  - Offline UPS (standby)
    - Only supplies power *when power is interrupted*
    - Switchover time can be a problem
    - Square nature of sine wave can cause problems
    - Only conditions power during interruption



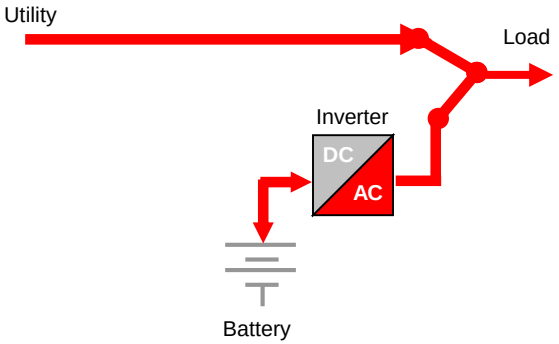
Standard Operation



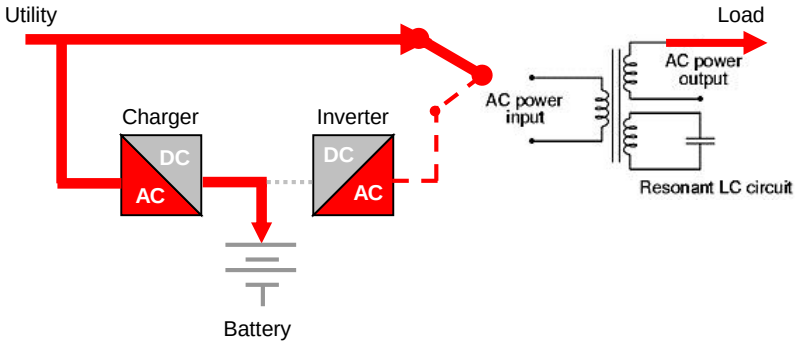
Power Interruption

Uninterruptible Power Supplies

- Uninterruptible Power Supply (UPS)
  - Hybrid or line-interactive UPS
    - Supplies additional power during sags
    - Provides some power conditioning
  - Hybrid direct ferroresonant transformer
    - UPS supports voltage regulation of ferroresonant transformer
    - Maintains output briefly when a total outage occurs
    - Can be unstable with PF-corrected power supply loads



Line-interactive Standard Operation



Ferroresonant Transformer

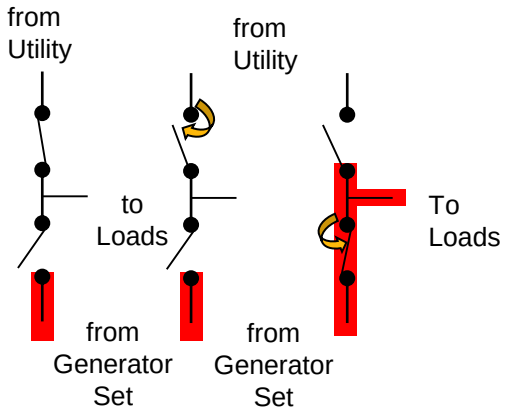
Uninterruptible Power Supplies

- Uninterruptible Power Supply (UPS)
  - Is your UPS *Uninterruptible*?
  - Does your UPS provide power conditioning?
  - Does your UPS provide electrical isolation?
  - What is your UPSs output waveform?
  - Does your UPS have a maintenance bypass?
  - How does your UPS detect a bad battery?
  - Is it modular to easily increase capacity?

Source: Liebert Corporation/Emerson Network Power

Equipment and Personnel Protection

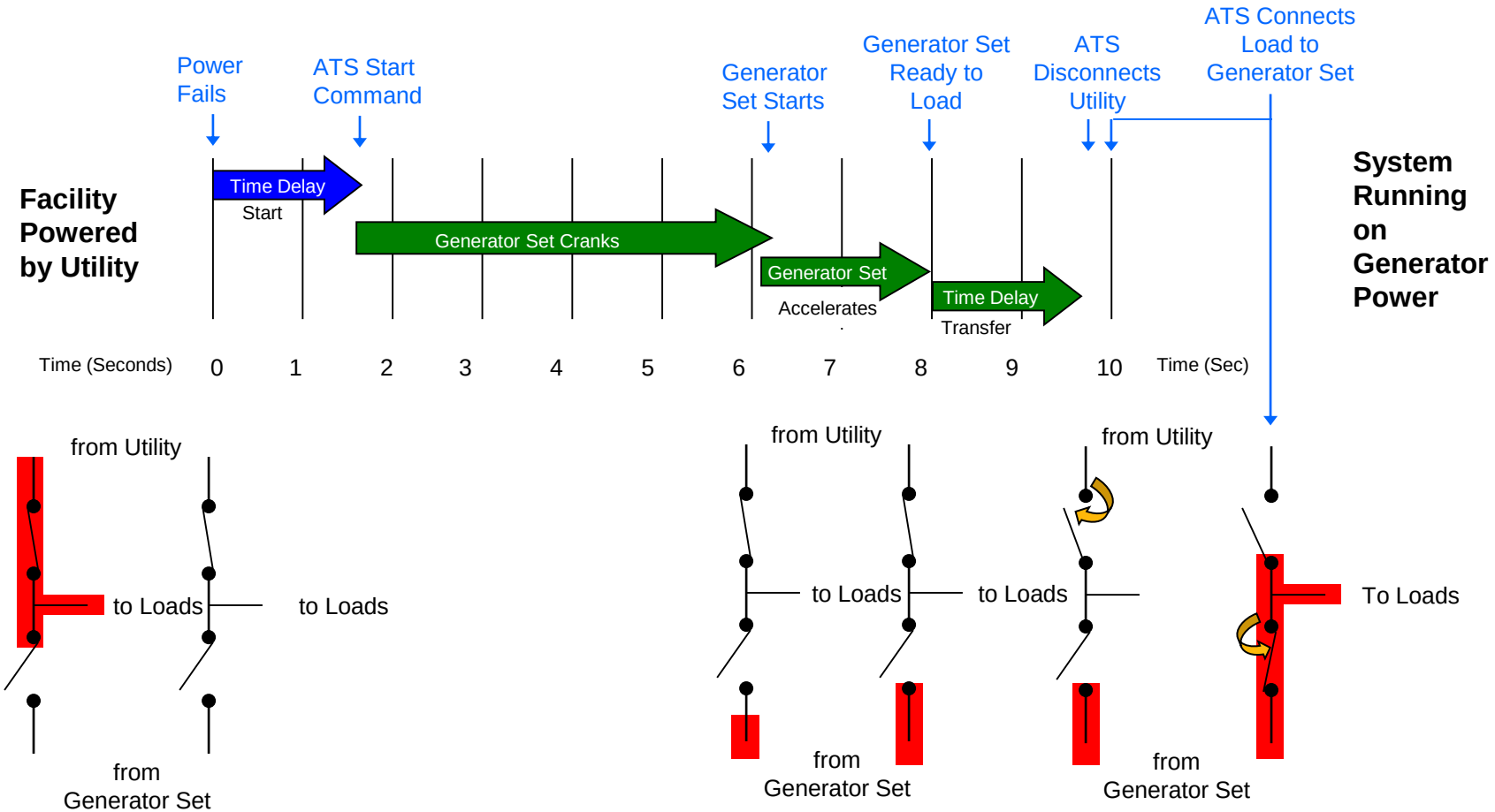
- Automatic Transfer Switches
  - Open-transition *break before-make* switching
    - Lowest cost
    - Most reliable
    - Requires one-half to three seconds decay interval



  - Fast closed-transition *make before-break* switching
    - Short-term paralleling of both sources
  - Soft closed-transition *make before-break* switching
    - Synchronizes and then gradually transfers the facility loads

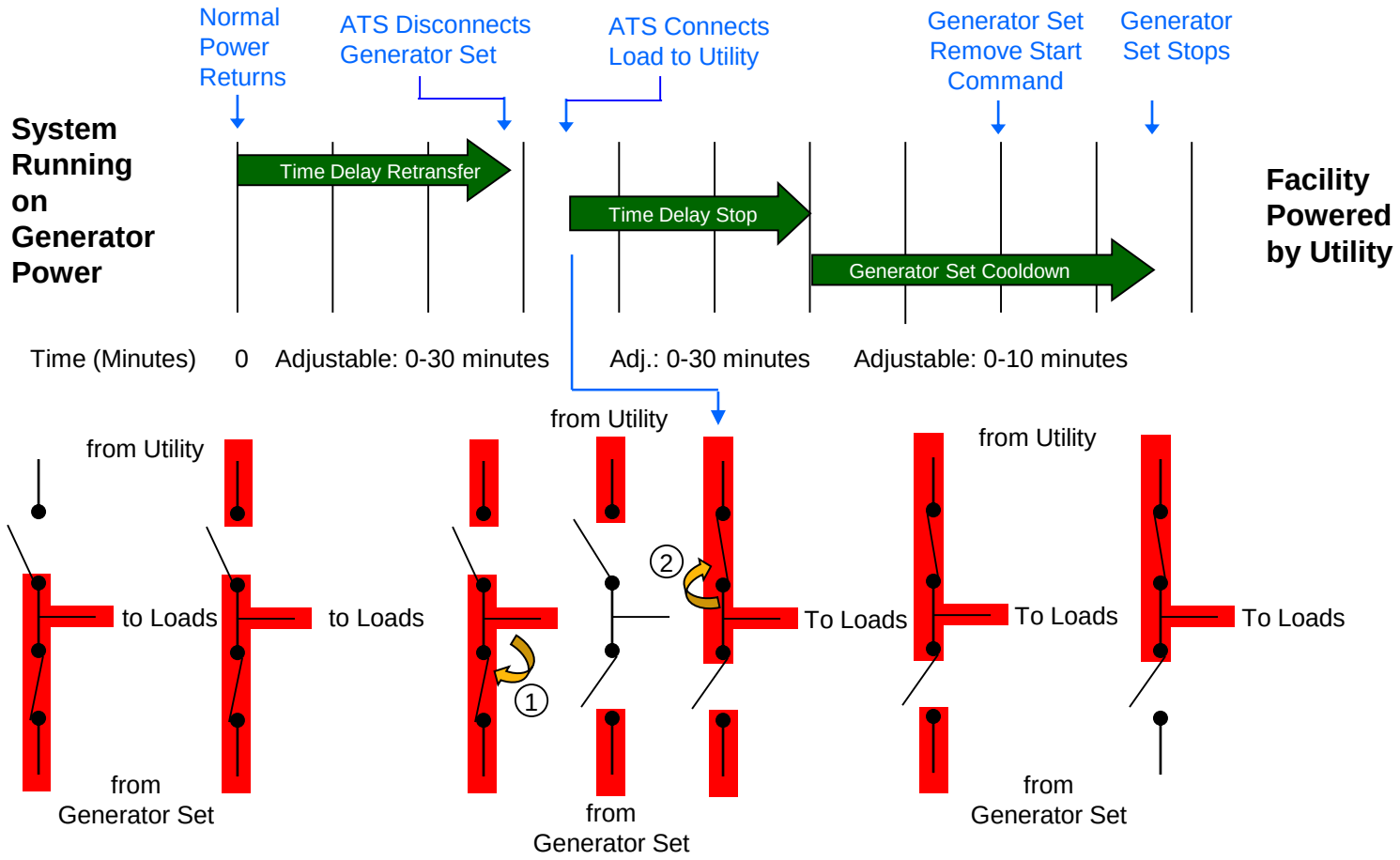
Equipment and Personnel Protection

- Automatic Transfer Switches (Open-Transition)



Equipment and Personnel Protection

- Automatic Transfer Switches (Open-Transition)

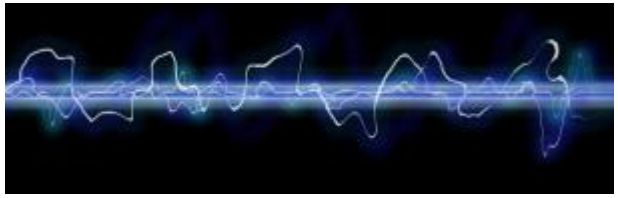


Poll Question

- Which type of UPS combines the best power conditioning with no switchover time?
  a) Hybrid
  b) Off-line
  c) On-line

Equipment and Personnel Protection

- Generator Compatibility with UPS
  - UPS feeds non-linear harmonics to generators
    - Power pulsations upon load changes
    - Overheating
    - *Bypass not available* alarms from the UPS



  - Possible Solutions
    - Oversize the generator (2 to 5X UPS rating)
    - Add linear loads to generator (even a load bank)
    - Increase generator insulation from class F to class H
    - Specify lowest temperature rise alternator
      - Typically 105ºC rise over a 40ºC ambient
    - Specify a generator set reactance/impedance of 15% or less.
    - Specify high-speed automatic voltage regulators (AVRs)
      - That provide pulse-width modulated output
    - Separately power the AVR
      - Use permanent magnet generator (PMG) supported excitation system

Codes and Standards

- NFPA 110, Standard for Emergency and Standby Power Systems
  - Run 30 minutes monthly (Section 8.4.2)
    - Minimum exhaust gas temperatures as recommended by the manufacturer
    - 30% minimum load, or
    - Available load and annual 2 hour test
  - Three classifications of generators
    - Type
    - Class
    - Level

Codes and Standards

- NFPA 110 Emergency Power System **Types**
  - **Type** refers to the maximum time that an emergency power system can remain unpowered after a failure of the normal source

Type	Power restoration time
U	Basically Uninterruptible (UPS Systems)
10	10 seconds
60	60 seconds
120	120 seconds
M	Manual stationary or non-automatic No time limit

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Codes and Standards

- NFPA 110 Emergency Power System **Classes**
  - **Class** refers to the minimum time, in hours, for which the system is designed to operate at its rated load without being refueled or recharged
    - Fuel storage shall be 133% of rating
      - Class 48 would have 64 hours of fuel storage

Class	Operation time before refueling
0.083	0.083 hour (5 minutes)
0.25	0.25 hour (15 minutes)
2	2 hours
6	6 hours
48	48 hours
X	Other time, in hours, as required by the application, code, or user

Codes and Standards

- NFPA 110 Emergency Power System **Levels**
  - The **Level** of an emergency power system refers to the level of equipment installation, performance, and maintenance requirements
  - Example: Level 1, Type 10, Class 48
    - Critical to life, 10 second start, 48 hours of operation

Level	Performance requirement
1	When failure of the equipment to perform could result in loss of human life or serious injuries
2	When failure of the equipment to perform is less critical to human life and safety and where the authority having jurisdiction shall permit a higher degree of flexibility than that provided by a level 1 system

Codes and Standards

- Hospitals and Other Healthcare
  - The Joint Commission (JCAHO)
    - Research and critical care functions are load-intensive systems
    - Redundancy essential
      - Requires backup generators regardless of how many feeders are available
      - At least one generator must always be available as a backup for N+1 redundancy
      - Generators must be tested for a minimum of four (4) continuous hours at least once every 36 months (EC.02.05.07)
  - NFPA 99 Health Care Facilities Code
    - 12 load tests per year
    - Test methodology from NFPA 110

Source: www.sxc.hu

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Codes and Standards

- Backup Generators—National Electrical Code (NEC)
  - Article 695—Fire Pumps (stationary pumps for fire protection)
  - Article 700—Emergency Systems
    - Article 700.27—Overcurrent Protection (Selective) Coordination
  - Article 701—Legally Required Standby Systems (health care, and so on)
    - Article 701.18—Overcurrent Protection (Selective) Coordination
  - Article 702—Optional Standby Systems (permanent and portable)
    - Article 702.6—Transfer Equipment (now allows parallel operation)
    - Article 702.9—Wiring Optional Standby Systems (allows sharing)
    - Article 702.10—*Portable* Generator Grounding (non-separately derived bonding)
  - Article 705—Interconnected Electric Power Production Sources (in parallel with a primary source)
    - Article 705.22—Disconnect Device (marked as may be energized from both sides)
    - Article 705.40—Loss of Primary Source (islanding protection and phase synching)

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Codes and Standards

- Backup Generators—National Electrical Code (NEC)
  - Article 708—Critical Operations Power Systems
    - Article 708.54—Overcurrent Protection (Selective) Coordination
  - Article 445—Generators
    - Article 445.13—Ampacity of Conductors
      - Requires 115% overcurrent protection
      - Neutral conductor sizing per Article 220.22—Feeder or Service Neutral Load
    - Article 445.18—Disconnecting Means Required for Generators
      - Switch or circuit breaker required unless engine can be easily stopped **and** generator not in parallel with another generator or source

Generator Tips

- Sizing Backup Generators
  - Consult a generator specialist
    - Caterpillar SpecSizer
    - Cummins Power Suite
    - Generac Power Design Pro
    - MTU Onsite Energy PS-Spec 4.0
    - Kohler QuickSize
  - Should be sized to run at full load operation in the 60% to 80% range of the generator capacity
  - Factor in inrush current during motor starting

Source: Stock.xchng

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Poll Question

- Would you like someone from PSE&G to call and provide guidance on backup generators?
  a) Yes
  b) No
- How valuable has this Webinar been to you?
  a) Not valuable at all.
  b) Slightly valuable.
  c) Moderately valuable.
  d) Very valuable.
  e) Extremely valuable.

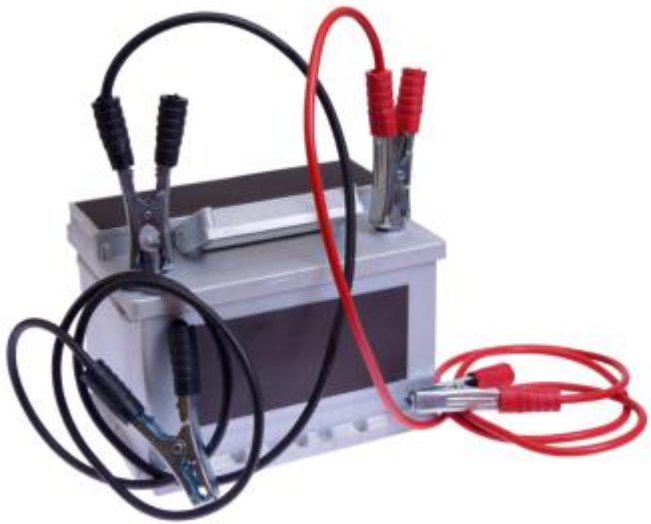
Generator Tips

- Tips for Buying a Used Generator
  - Check the hours, age, and history of the generator set.
  - Consider the generator manufacturer's history and reputation
  - Check the seller's current level of knowledge on maintaining and repairing diesel engines, power units, transfer switches, and generator ends
  - Check all mechanical components for wear or fatigue.
  - The bearings and bushings should all be replaced, regardless of their function or condition
  - Integrity check wiring and welds
  - Request a load test
  - Insist on a guarantee or limited warranty for a period of one to three months after your purchase

Source: Diesel Service & Supply, Inc. (Brighton, CO)

Generator Tips

- Top Nine Reasons Generators Fail to Start
  1. Battery failure
  2. Low coolant levels
  3. Low coolant temperature alarms
  4. Oil, fuel, or coolant leaks
  5. Controls *not in auto*
  6. Air in the fuel system
  7. Ran out of fuel
  8. High fuel level alarm
  9. Breaker trip



Source: Darren Dembski of Peterson Power Systems

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Questions?

- Contact Information:
  - Email:
    - LargeCustomerSupport@pseg.com
  - Phone:
    - 1-855-249-7734
  - Websites:
    - http://www.pseg.com/business/small_large_business/index.jsp
    - http://www.njcleanenergy.com/

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