Meet Your Panelists:

Mike Carter
Sr. Engineer, CEM

Consumers Energy Subject Matter Experts:

Tim Voss, Corporate Account Manager, Business Customer Care
Mark Shaw, Senior Engineer II, PE (Professional Engineer)
• Reliability Cost
• Backup Power Options
  ▪ Generators
  ▪ Uninterruptible Power Supplies
• Generator Switchover
• 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

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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)

Source: AMR Research

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Reliability Cost

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

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Backup Power Options

- Redundancy
- Generator
- UPS
- Power Conditioning
- Surge Protection Devices
- Good System Design
- Wiring and Grounding

Source: Liebert Corporation

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Backup Power Options

• Consumers Energy is here to help

Products and Services

We take pride in the breadth of products and services we’re able to provide to our business customers.

In fact, we’re prepared to help you in ways you may never have imagined, from transformer installations to training employees.

But keep in mind, no matter which services or programs you choose, ultimately they’re all intended to do the same thing: improve your firm’s performance.

That’s because at Consumers Energy, we believe our business is only as strong as the businesses we serve.

So, take a look. You’ll see it’s time we got down to business together.

You can get more information by completing the Business Products and Services form.

Contact our customer service specialists by telephone toll-free at (800) 865-0400 or e-mail businesscenter@consumersenergy.com

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Backup Power Options

• **Backup Generators**
  - **Capital costs**
    - Roughly 50% of the purchase cost, and can approach $10,000 for a 100 kW unit
    - Does not change drastically with size, so there is no penalty for oversizing
  - **Installation costs**
    - Roughly 50% of the purchase cost, and can approach $10,000 for a 100 kW unit
    - Does not change drastically with size, so there is no penalty for oversizing
  - **Maintenance costs**
    - $500 to $1,000 per year
    - Includes an oil change and tune up every 1,500 hours
    - Diesels considered most mechanically reliable

<table>
<thead>
<tr>
<th>Capital Costs, $/kW</th>
<th>Diesel</th>
<th>Natural Gas</th>
<th>Micro-turbine</th>
<th>Fuel Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>$150-$250</td>
<td>$200-$300</td>
<td>$1,000</td>
<td>$3,000-$4,000</td>
<td></td>
</tr>
</tbody>
</table>

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Backup Power Options

**Backup Generator Fuel Use**

- Operating cost of $0.10 to $0.30/kWh range
  - Be sure to include electric demand charges for comparison
- Diesel costs 2X more than natural gas

<table>
<thead>
<tr>
<th>Standby Rated kW</th>
<th>200 kW</th>
<th>500 kW</th>
<th>1,500 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>Gallons/hr</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>CCF/hr</td>
<td>18</td>
<td>43</td>
</tr>
</tbody>
</table>

Source: Detroit Diesel & Caterpillar
Which of the following costs are typically incurred by companies when a power outage occurs?

a) Lost sales revenue  
b) Lower employee productivity  
c) Lost customers  
d) Damaged image
Backup Power Options – Natural Gas

• 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 - Diesel

- Backup Generator Fuel Sources
  - Diesel Advantages:
    - Efficiency curve for diesel engines is comparatively flat
    - Easily obtained
    - Onsite fuel delivery available
    - Portable
  - Diesel 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 - Propane

• **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—gas 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)
Backup Generator Fuel Sources

Gasoline Advantages:
- Common fuel source—easily obtained
- Increases portability of smaller generators
- Cost effective for infrequent usage

Gasoline Disadvantages:
- Highly flammable
- Short shelf life (approximately 12 months)
- Storing large quantities is hazardous
- May not be available during power outages
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 Health Care Facilities
- NFPA 110, Standard for Emergency and Standby Power Systems
- UL 1008 Automatic Transfer Switches

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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)
    • (COPS) Critical operations power systems (NEC Article 708)
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**
  - 10 second response
  - No diversity demand factors (100% fault current)
  - 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
Emergency System Operating Restrictions

- No limit on operation during normal utility outages
- 100 hour limit for maintenance and testing
  - 50 hour limit for non-emergency situations
  - 15 hour limit for “emergency” demand response
- No peak shaving
- Further restrictions or allowances in local codes may apply
Backup Power Options

- **Standby Power System**
  - Response time
    - 60 seconds for legally required
    - No requirement for optional standby
  - Demand factors **allowed**
  - Combined circuits
  - Acceptance/operational testing required under load

Source: NREL

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Backup Power Options

• **Standby Power System**
  - Ground fault response
    - Alarm for legally required
    - Protection for optional standby and 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

Source: Tut Wanders, Creative Commons
Backup Power Options

• Commercial Building with COPS

Emergency  Legally Required  Optional  COPS

Source: TLC Engineering for Architecture

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# Backup Power Options

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

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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

<table>
<thead>
<tr>
<th>Avg. Load</th>
<th>UPS Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>93%-97%</td>
</tr>
<tr>
<td>30%</td>
<td>89%</td>
</tr>
<tr>
<td>10%</td>
<td>50%</td>
</tr>
</tbody>
</table>
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 - Online

- **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
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
Uninterruptible Power Supplies - Hybrid

- **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

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**Line-interactive Standard Operation**

- Utility
- Inverter
- Load
- Battery

**Ferroresonant Transformer**

- Utility
- Charger
- Inverter
- AC power output
- Battery

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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?
    - One blade server will replace 20 tower servers and use half the space but consume 3 to 5 times as much power

Source: Liebert Corporation/Emerson Network Power
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
  - Paralleling of both sources (<100 milliseconds) during the transfer period
  - Requires splitting the loads into small portions and controlling transfer sequence
  - Frequency transients will be imposed on the system
    - May be just as disruptive (or worse) as a short total interruption

- Soft closed-transition *make before-break* switching
  - Synchronizes and then gradually transfers the facility loads
  - Typical disturbances in voltage and frequency are eliminated
Generator Switchover

Automatic Transfer Switches (Open-Transition)

- Power Fails
- ATS Start Command
- Generator Set Starts
- Generator Set Ready to Load
- ATS Disconnects Utility
- ATS Connects Load to Generator Set

Facility Powered by Utility

Time (Seconds) 0 1 2 3 4 5 6 7 8 9 10

Time Delay
Start

Generator Set Cranks

Generator Set Accelerates
Transfer

ATS Disconnects Utility

ATS Connects Load to Generator Set

System Running on Generator Power

To Loads

from Utility

to Loads

from Generator Set

from Utility

to Loads

from Generator Set

from Utility

to Loads

from Generator Set

To Loads

from Utility

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Generator Switchover

Automatic Transfer Switches (Open-Transition)

- System Running on Generator Power
- Normal Power Returns
- ATS Disconnects Generator Set
- ATS Connects Load to Utility
- Generator Set Remove Start Command
- Generator Set Stops

- Time Delay Retransfer
- Time Delay Stop
- Generator Set Cooldown

Time (Minutes)

0 Adjustable: 0-30 minutes

Adjustable: 0-10 minutes

From Utility

To Loads

From Generator Set

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Poll Question

• Which type of UPS combines the best power conditioning with no switchover time?
  a) Hybrid
  b) Off-line
  c) On-line
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 105°C rise over a 40°C ambient
- Specify a generator set reactance/impedance of 15% or less.
- Specify high-speed automatic voltage regulators (AVRs) that provide pulse-width modulated output
- Use permanent magnet generator (PMG) supported excitation system to separately power the AVR
• 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
 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Power restoration time</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>Basically Uninterruptible (UPS Systems)</td>
</tr>
<tr>
<td>10</td>
<td>10 seconds</td>
</tr>
<tr>
<td>60</td>
<td>60 seconds</td>
</tr>
<tr>
<td>120</td>
<td>120 seconds</td>
</tr>
<tr>
<td>M</td>
<td>Manual stationary or non-automatic</td>
</tr>
<tr>
<td></td>
<td>No time limit</td>
</tr>
</tbody>
</table>
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.

### Power Restoration Time

<table>
<thead>
<tr>
<th>Class</th>
<th>Power restoration time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.083</td>
<td>0.083 hour (5 minutes)</td>
</tr>
<tr>
<td>0.25</td>
<td>0.25 hour (15 minutes)</td>
</tr>
<tr>
<td>2</td>
<td>2 hours</td>
</tr>
<tr>
<td>6</td>
<td>6 hours</td>
</tr>
<tr>
<td>48</td>
<td>48 hours</td>
</tr>
<tr>
<td>X</td>
<td>Other time, in hours, as required by the application, code, or user</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Level</th>
<th>When Installed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>When failure of the equipment to perform could result in loss of human life or serious injuries</td>
</tr>
<tr>
<td>2</td>
<td>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</td>
</tr>
</tbody>
</table>
Hospitals and Other Healthcare

- Service requirements
  - Three levels of criticality are used to define the different tolerances for power interruptions in a hospital setting

<table>
<thead>
<tr>
<th>Criticality Level</th>
<th>Continuity of service requirements</th>
<th>Max. duration for power cut &amp; switch to back-up</th>
<th>Minimum endurance of back-up power source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Permanent power supply</td>
<td>&lt; 0.5 seconds</td>
<td>3 hours</td>
</tr>
<tr>
<td>2</td>
<td>Brief interruption</td>
<td>&lt; 15 seconds</td>
<td>24 hours</td>
</tr>
<tr>
<td>3</td>
<td>Long interruption</td>
<td>&lt; 3 minutes</td>
<td>24 hours</td>
</tr>
</tbody>
</table>

Source: Schneider Electric
Hospitals and Other Healthcare

- Joint Commission for Accreditation for Healthcare Organizations (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)

Source: www.sxc.hu
Generator Nomenclature by Manufacturers

- **Standby**
  - Typically less than 100 hours of use per year
  - Variable load of 60% or less
  - Up to 80% of rated capacity for peak demand
  - Up to 100% of rated capacity for emergency operation

- **Prime**
  - Variable load 60% to 70%
  - Up to 100% of rated capacity typically less than 20% of time

- **Continuous**
  - Up to 100% of rated capacity for an unlimited amount of time
Codes and Standards - NEC

• **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)
• **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

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Poll Question

- **How valuable has this Webinar been to you?**
  
a) Not valuable at all. The content was too technical and detailed for me to understand.

b) Slightly valuable. It was worth attending, but I would not recommend it to anyone.

c) Moderately valuable. Content was interesting and informative, but only increased my knowledge or comfort level with backup generators a little.

d) Very valuable. This was time well spent and I learned a lot.

e) Extremely valuable. My knowledge of backup generators has increased considerably.
Generator Tips - Sizing

• **Sizing Backup Generators**
  - Consult a generator specialist
  - 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
Generator Tips - Buying

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 - Starting

- **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
Questions?

Resources For You
- Sign up for our FREE Solution Center eNewsletter
  - Ask an Expert
  - Tools, calculators and energy-saving tips
  - All available online

Contact Us
- Website: www.ConsumersEnergy.com/business
- Phone: (800) 805-0490
- Email: businesscenter@consumersenergy.com

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