

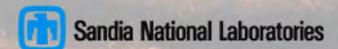


# Sandia National Laboratories Overview

SF<sub>6</sub> Emissions Overview  
Joanna Eckstein and Penny Avery



Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.



# Sulfur Hexafluoride Use at SNL/NM

- **Four primary processes utilize SF<sub>6</sub>. These processes include:**
  - Reactive Ion Etching
  - Transmission Electron Microscopes (TEM)
  - Flash X-Ray
  - Pulsed Power Applications (High Voltage Switching Devices)
- **Other various small processes are conducted throughout SNL/NM**

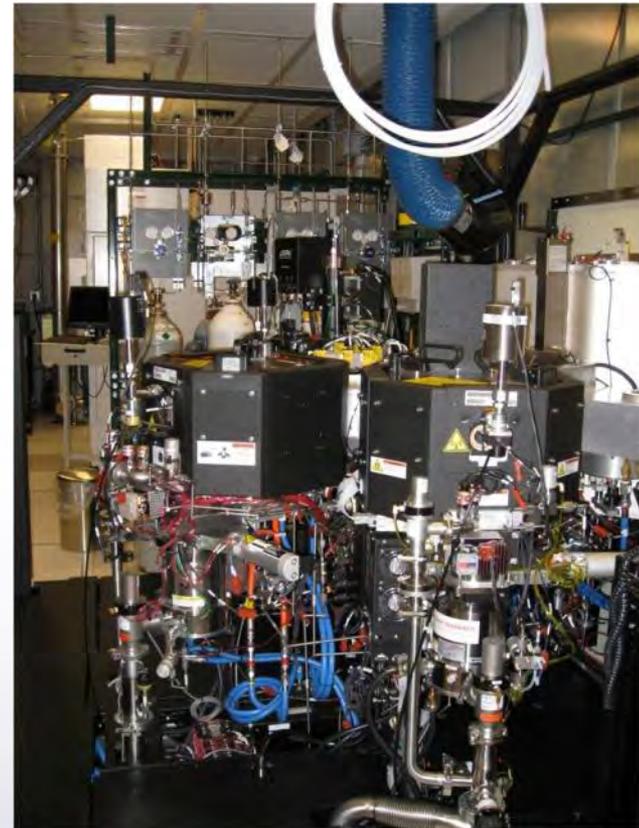


Z Machine at SNL/NM



# Reactive Ion Etching

- 6 reactive ion etchers at SNL/NM
- Minimal amount of  $\text{SF}_6$  during the process
- Potential  $\text{SF}_6$  emissions are not being recaptured
- Potential substitute chemicals include:
  - Carbon Tetra Fluoride ( $\text{CF}_4$ )
    - ◆  $\text{CO}_2\text{e} = 6,500$
  - Nitrogen Tri-Fluoride ( $\text{NF}_3$ )
    - ◆  $\text{CO}_2\text{e} = 8,000$



Reactive Ion Etching System at SNL/NM



# Transmission Electron Microscopes

- 4 TEM's at SNL/NM
- Manufactured to be used with SF<sub>6</sub> gas
- Potential SF<sub>6</sub> released occurs during maintenance operations (not recaptured)
- Maintenance releases are small and infrequent



Transmission Electron Microscope at SNL/NM



# Flash X-Ray for Research and Development

- Two types of X-Ray machines utilize SF<sub>6</sub>
  - Pulsers
  - Linear Accelerators
- SF<sub>6</sub> is injected into the chambers prior to a shot, purged after the shot (not recaptured)
- Used very infrequently in remote locations
- Potential to retrofit chambers to utilize air
- Cost of retrofit is between \$10K and \$15K per chamber.

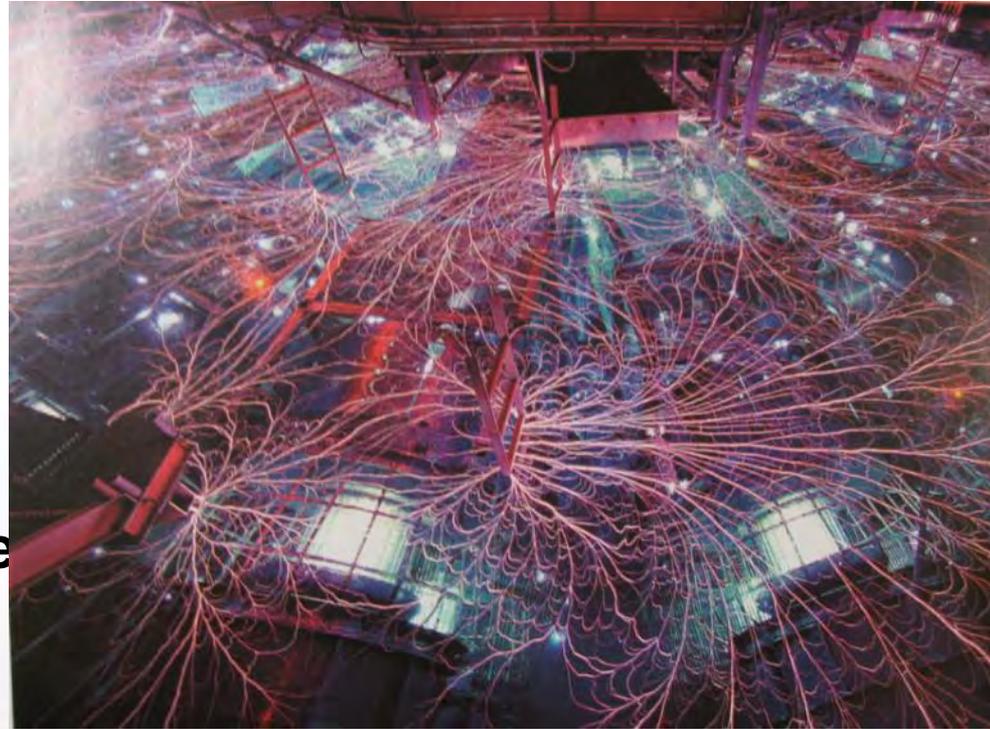


Pulsers at SNL/NM



# Pulsed Power Applications (High Voltage Switching Devices)

- Majority of the SF<sub>6</sub> at SNL/NM is used as an electrical insulator on pulsed-power R&D installations
- Prevent premature triggering of high-voltage switching devices
  - Spark gaps
  - Cascade switches



The Z Machine in operation at SNL/NM



# Z Machine SF<sub>6</sub> Reclamation Systems



Control Room for the Processing and Recovery Plant



SF<sub>6</sub> Storage Tanks for the Processing and Recovery Plant

- Large-scale SF<sub>6</sub> processing and recovery plant to support routine operations
- Quantity maintained within the plant is administratively limited (4,100 lb max)

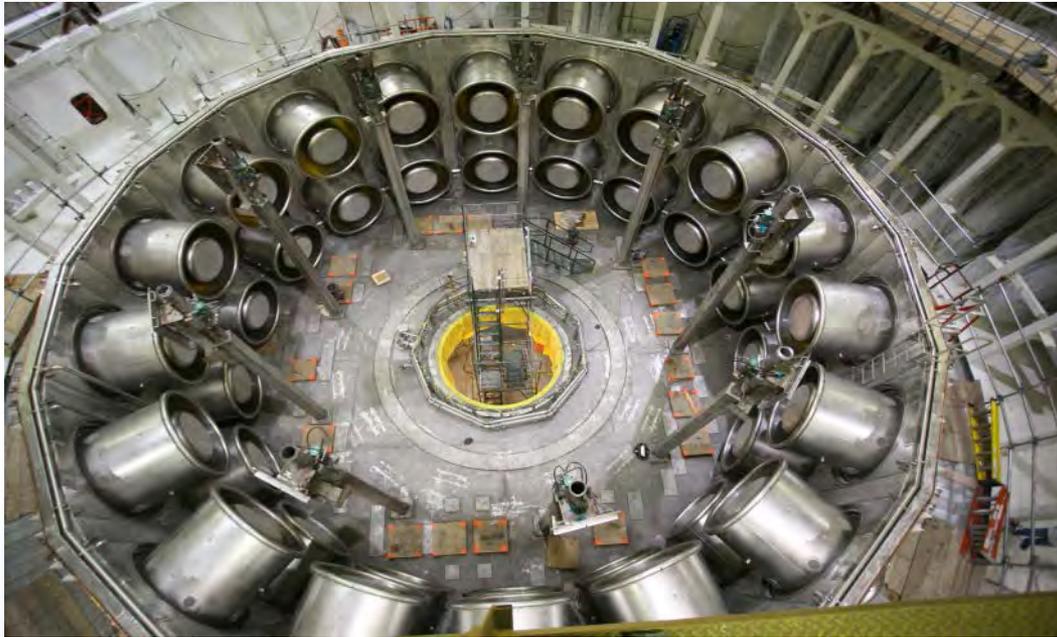


Portable Gas Reclamation Units

- Portable gas reclamation units are used for certain maintenance activities
- Quicker and more efficient than the plant
- Used to temporarily support routine Z Machine operations when the plant is off-line for maintenance or repairs



# Z Machine Operations



Z Machine

- **SF<sub>6</sub> losses are estimated to be within the range of 200-300 lbs per week**
  - component damage
  - undetected mechanical connection leaks

- **Most efficient and powerful X-Ray source in the world**
- **Fielding 100-200 experiments per year!**



Z Machine



# High Energy Radiation Megavolt Electron Source (HERMES)



SF<sub>6</sub> Reclamation Unit

- Up to 2 shots per day
- Reclamation Unit attached
- There is a SF<sub>6</sub> loss with each shot



SF<sub>6</sub> Switches



# Saturn Facility



SF<sub>6</sub> Gas Switch



SF<sub>6</sub> Reclamation Unit



MARX Generator Bank

- Up to 2 shots per day
- Reclamation Unit attached
- There is a SF<sub>6</sub> loss with each shot



# Tracking of SF<sub>6</sub> Purchases at SNL/NM



## Chemical or Tradename Result

[View Report in Excel](#)

[Return to Search Page](#)

Tradename: [SULFUR HEXAFLUORIDE](#)  
MSDS: OHS22300  
Site: SNL/NM  
Building (Wildcard): 518  
Report Type: Individual Containers  
Group By: Location  
Physical States: Solid Liquid Gas Aerosol

Barcode	Location	Org.	Quantity	Report Quantity	Purchase Date	Transfer/Remove
<a href="#">AQ00634444</a>	<a href="#">NM/518/1519</a>	<a href="#">01131</a>	100.0 LBS	801.7 CUFT	03/15/2007	<input type="checkbox"/>
<a href="#">AQ00687974</a>	<a href="#">NM/518/1531</a>	<a href="#">01132</a>	35.0 LBS	280.6 CUFT	10/28/2008	<input type="checkbox"/>
<a href="#">AQ00149258</a>	<a href="#">NM/518/GAS</a>	<a href="#">01132</a>	250.0 CUFT	250.0 CUFT	08/11/1997	<input type="checkbox"/>

Number of containers: 3

[Update Containers](#)

[Reset](#)

[Return to Chemical or Tradename Search](#)

[View Report in Excel](#)

Contact [cjs@sandia.gov](mailto:cjs@sandia.gov) for CIS feedback or [cchd@sandia.gov](mailto:cchd@sandia.gov) (Corporate Computing Help Desk) for application feedback.



Application Version: Release 1.1.20, Last Modified: August 25, 2010





# Chemical Information System (CIS)

## Advantages

- All of SNL/NM chemical purchases are tracked
- Online barcode system
- Purchases linked to a specific location and individual
- Numerous customizable functions
  - Customizable queries
  - Purchase reports
  - Chemical reports
  - Date Range, etc.

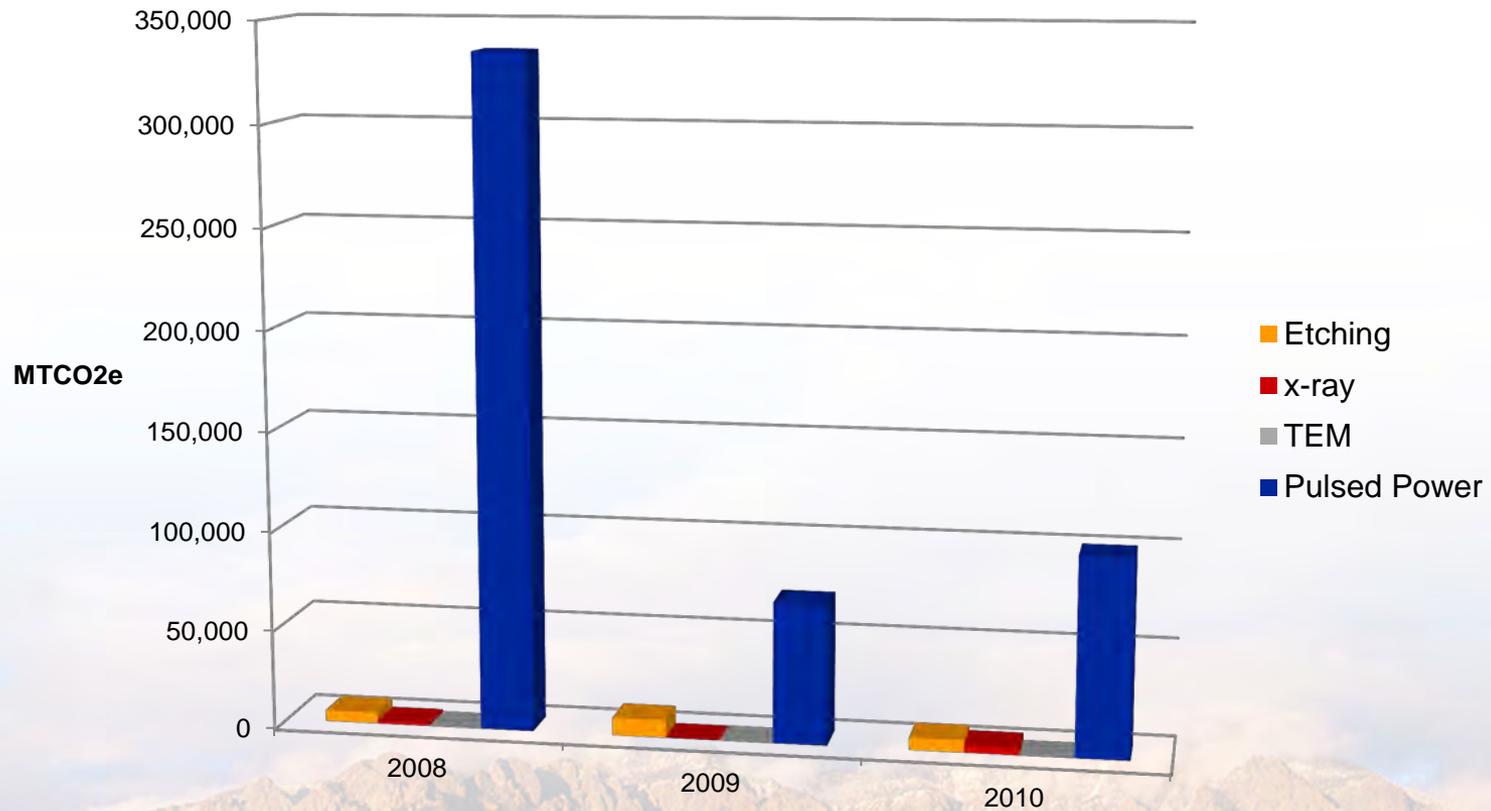
## Limitations

- Inventory of chemical assume containers to be 100%
- Potential user errors:
  - The user is responsible
  - Location of the chemical
  - Scanning the chemicals “out”



# Analysis of Purchase Data

- Pulsed Power is the largest SF<sub>6</sub> purchaser at SNL/NM

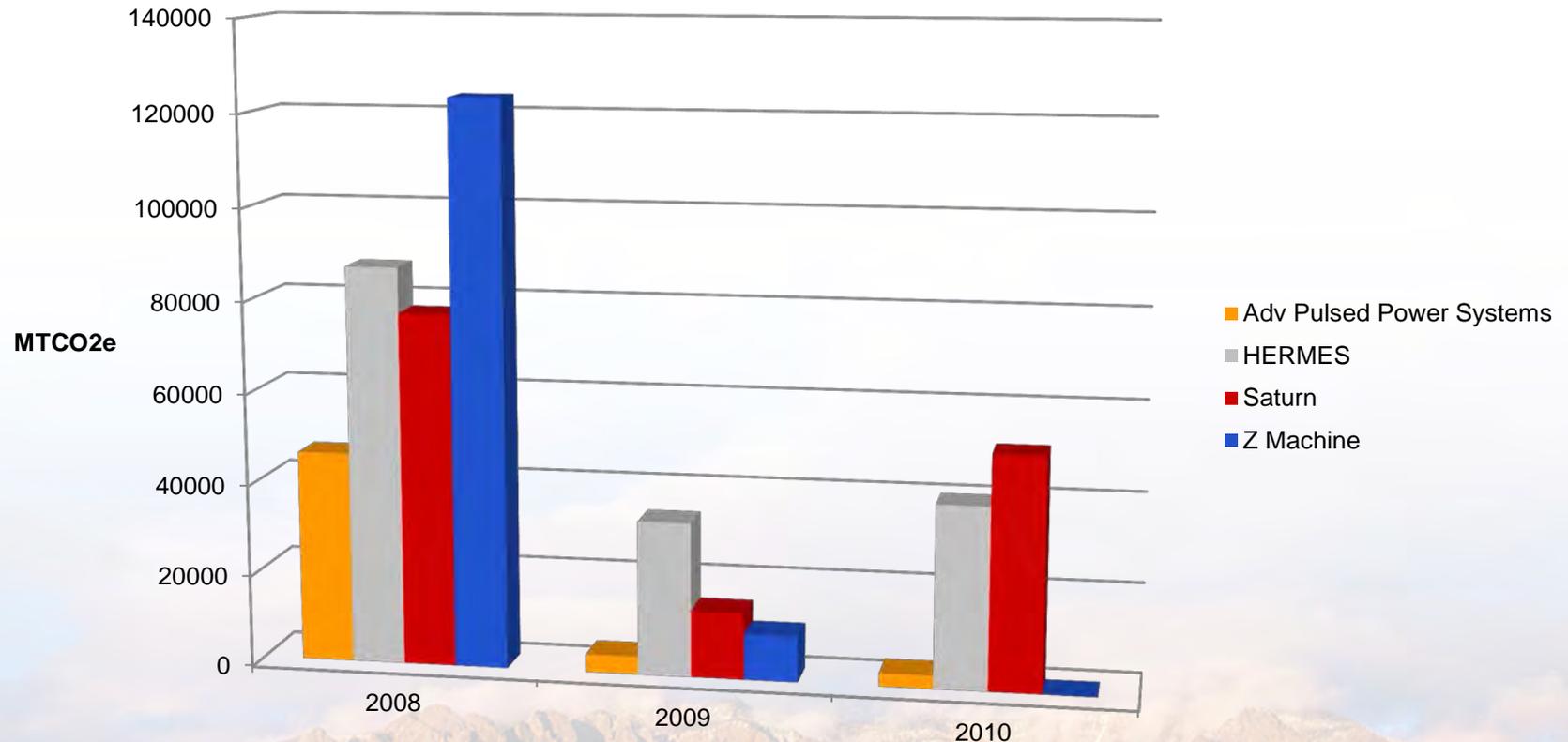


Note: Data is based on Fiscal Year purchases (October thru September )



# Analysis of Pulsed Power Purchase Data

## ■ Purchase data is extremely conservative



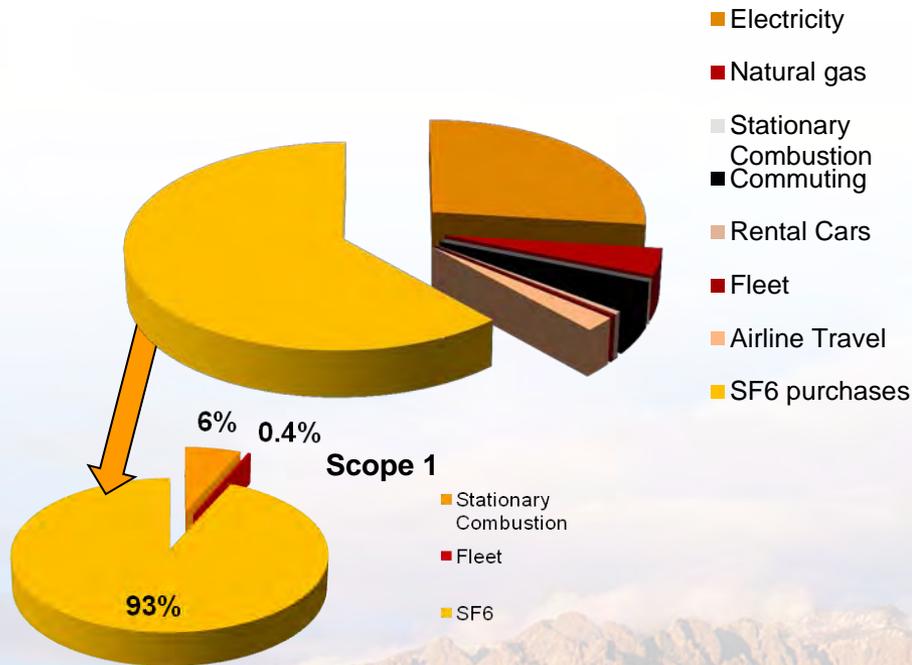
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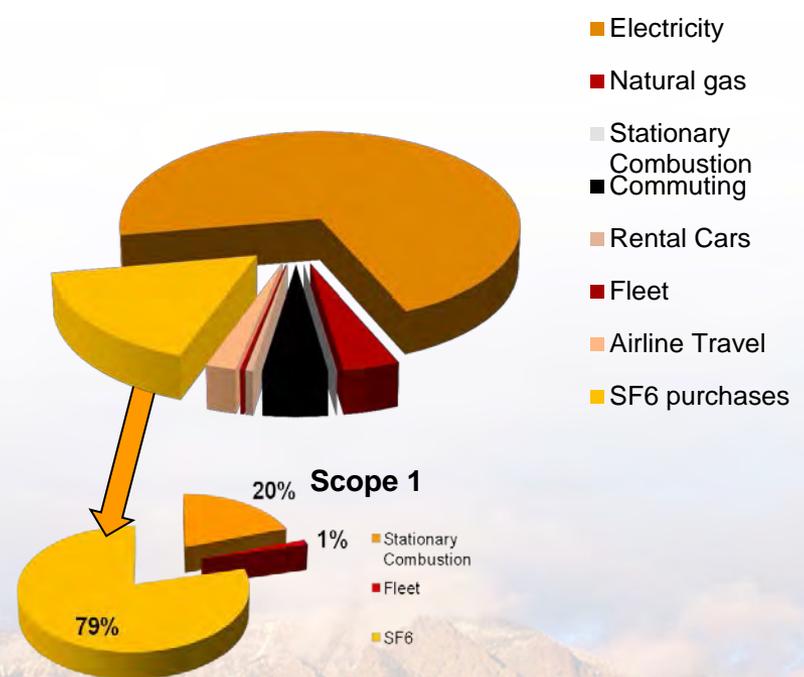
# SNL/NM GHG Emissions Breakdown

## ■ Impact of SF6 purchases on facility-wide GHG profile

### FY2008 GHG Emissions



### FY2009 GHG Emissions



# ★ Proposed Pulsed Power SF<sub>6</sub> Reduction Strategies

Reduction Measures	Status	Additional Possibilities	Challenges
Reclamation	All pulsed power units and other larger users must utilize reclamation systems	Portable reclamation units to reduce some of the “intentional releases”	<ul style="list-style-type: none"> <li>• Larger pulsed power facilities have thousands of connection points which can potentially leak</li> <li>• Energy released during shots (&gt;1,000x the electricity of a lightning bolt) stresses all of the connections</li> <li>• Remote locations and low SF<sub>6</sub> usage at several facilities reduce the practicality of portable reclamation units</li> </ul>
Substitution	Currently not a reasonable alternative to SF <sub>6</sub> without major reconfiguration of equipment and processes	Potential alternatives and necessary reconfigurations for high voltage and other applications are being reviewed	<ul style="list-style-type: none"> <li>• Alternatives are typically also GHG's, or have other increased safety hazards</li> <li>• Alternatives typically require operation at significantly higher pressures</li> <li>• Equipment using substituted gas would require complete recalibration and significant equipment substitutions</li> </ul>
Other Controls	Pulsed power facilities conduct routine leak detection and minimization activities	Employee training to ensure that anyone handling SF <sub>6</sub> will minimize releases	<ul style="list-style-type: none"> <li>• Leak detection activities at pulsed power facilities are conducted and effective               <ul style="list-style-type: none"> <li>• Repairs are completed immediately</li> <li>• However, numerous small leaks over large numbers of connections results in some loss of gas after every shot</li> </ul> </li> </ul>





# Summary

- Pulsed power accelerators store electrical energy, compress it in time and space, and deliver the energy to a target as strong, short, fast-rising pulses of power.
- SNL/NM operates several pulsed power facilities of varying power levels and capabilities.
- SF<sub>6</sub> is an integral part of the pulsed power process and is the best electrical insulator available.
- Although the vast majority of SF<sub>6</sub> is already being captured and re-used, SNL/NM faces challenges in further reducing SF<sub>6</sub> emissions from equipment with thousands of connections, and therefore potential leak points, which undergo extreme physical stresses.

