

# Resilience Metrics

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*Prepared for*  
**Quadrennial Energy Review Technical Workshop on  
Resilience Metrics for Energy Transmission and Distribution Infrastructure**  
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# Infrastructure Assurance Center

- Started as a follow on to work on the PCCIP in late 90s
  - Focused on critical infrastructure protection initially
  - Morphed into focus on resilience
- ECIP program and RRAP
- Center for Integrated Resilience Analysis
  - The CIRA vision is “to develop, use, and promote a systematic approach to create integrated system-of-systems solutions and tools for resiliency analyses in support of National Security issues.”
  - Created in Jan 2014, CIRA is a virtual center located in DIS, but will coordinate efforts across DIS and the laboratory.
  - CIRA will utilize existing ANL capabilities in areas such as:
    - High performance computing
    - Climate modeling
    - Energy systems modeling
    - Complex adaptive systems



# Metrics Development

- Identify goals and objectives
- Characteristics of good metrics
  - Comprehensive
  - Understandable
  - Practical
  - Non-redundant
  - Minimal
- The above create defensible, transparent and repeatable metrics
- Metrics for different purposes and levels
  - Performance based vs. strategic
- Industry focused on outcomes
  - Work with their goals to gauge resilience
  - Non-outcome based could be equally meaningful but harder to internalize



# Infrastructure Resilience

- Collecting and measuring critical infrastructure protection and resilience for 16 sectors
- Resilience, in the context of critical infrastructure, is defined as the ability of a facility or asset to anticipate, resist, absorb, respond to, adapt to, and recover from a disturbance (*Resilience: Theory and Applications, ANL, 2013*)
- Development of an indicator of resilience focusing on 4 major components
  - preparedness, mitigation measures, response capabilities, and recovery mechanisms
- Each of the 4 main components captures several more detailed components of resilience
  - Preparedness: Awareness and Planning
  - Mitigation Measures: Mitigating construction, Alternate Site; Resources Mitigation Measures (dependencies)
  - Response Capabilities: Onsite and offsite capabilities, Incident management and command center characteristics
  - Recovery Mechanisms: Restoration agreements and Recovery Time



# Some Specifics

- Plans (Emergency Action Plans and Business Continuity Plans)
  - What types of threats and hazards do the plans address
  - Who is aware of the plans and how are they distributed
  - Are the plans trained and exercised (especially with external responders) regularly
  - Are the plans periodically reviewed
- Backup Measures
  - What types of backups are in place and what are they meant to cover
  - How long will the backup last before needed fuel
  - Are their contingency and/or priority plans in place
- Information sharing practices and awareness
- Are there regulations in place that keep you from implementing measures that you would like to implement



# DHS Enhanced Critical Infrastructure Protection (ECIP) Initiative

- DHS Initiative
  - DHS Protective Security Advisors (state-based) visit nationally critical assets
  - Information shared with owners/operators
- Argonne involvement
  - Designed risk-based methodology
  - Developed data collection tool
  - Developed dashboards of analysis results
- Protective and Resilience Indices
  - Provides survey of existing protective and resilient measures that are in place at facility
  - Collects information for protective and resilience related attributes and calculates a Protective Measurement Index (PMI) and Resilience Measurement Index (RMI)

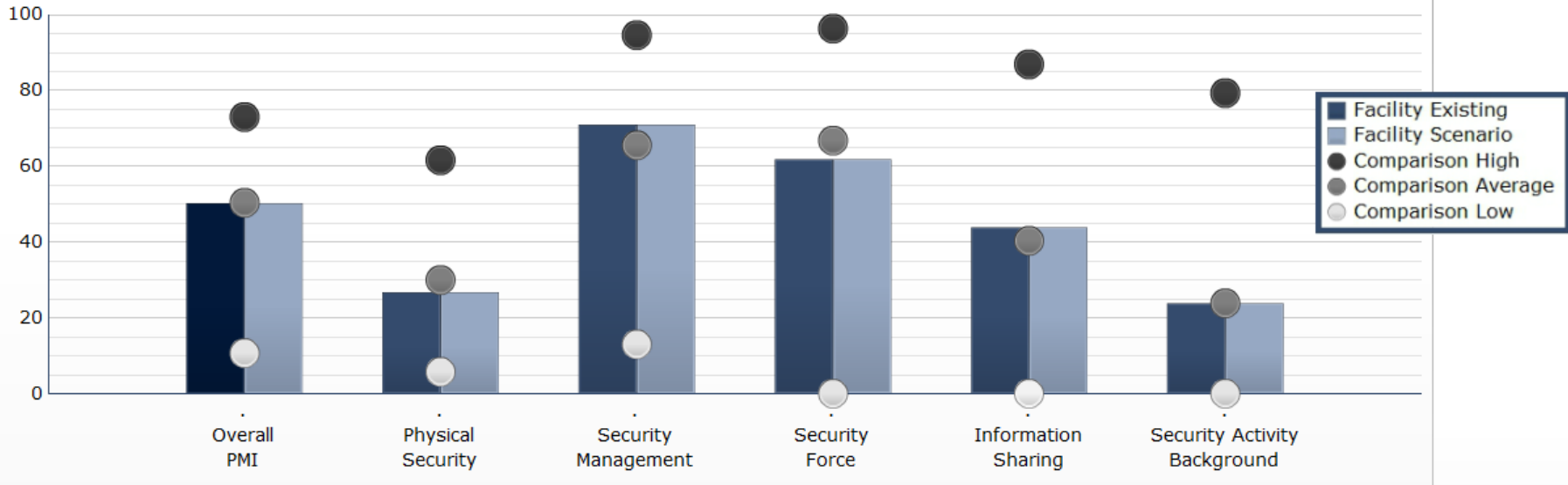




- Overview
- Physical Security
- Security Management
- Security Force
- Information Sharing
- Security Activity Background
- Brief Review

- Facility Overview
- SAA Overview

### Overall Protective Measures Index



Sample Office Building

To view the details of any element, click on the corresponding light blue "Facility Scenario" bars on the chart above.

Compared to 120 other Office Building - Stand Alone

Survey Date  
2/6/2013

Compilation Date  
2/6/2013



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4. CCTV

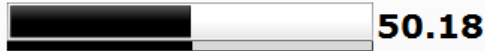
2. Monitor

Does the facility utilize CCTV?  No  Yes

### Who monitors the CCTV cameras?

- No real-time monitoring (only review recorded information)
- Non-security personnel (e.g., receptionist)
- Trained, but not dedicated, security staff
- Dedicated, 24/7 trained security staff
- Y**  Law enforcement monitoring in addition to facility staff **N**

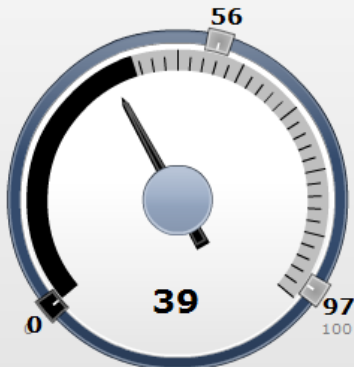
### Overall PMI



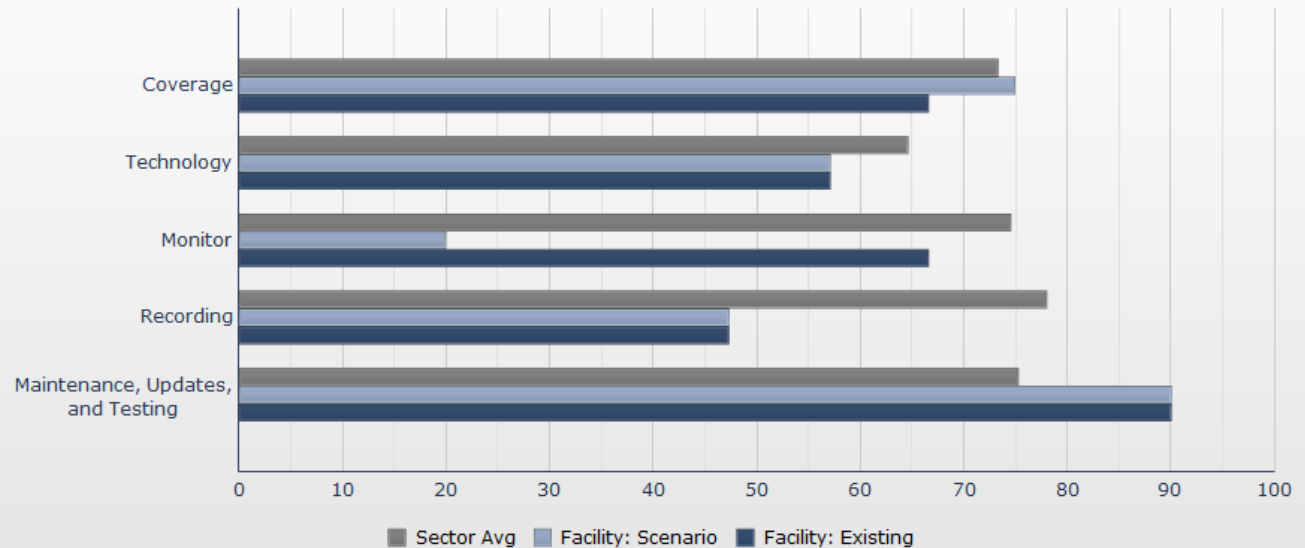
### Physical Security PMI



### CCTV PMI



### CCTV





# DHS Regional Resilience Assessment Program (RRAP) Initiative

- DHS Initiative (2009) that builds on ECIP capability to address resilience of national critical infrastructure beyond the single asset
- More complex problem
  - Need to address dependencies, interdependencies, cascading effects, regional resilience capabilities, and security gaps
- IAC Involvement
  - Re-designed critical infrastructure risk-based methodology to include resilience considerations
  - Assisted in formulating processes to capture regional resilience picture
  - Developed first dependency dashboards
  - Used IAC developed sector-specific modeling tools to enhance regional analysis
- Suite of output products
  - Survey of existing protective and resilient measures that are in place at facilities to produce facility Resilience Measurement Index
  - Summary of facilitated discussions with stakeholders
  - Dependency curves
  - Report that synthesizes information and highlights key findings



# Dependencies

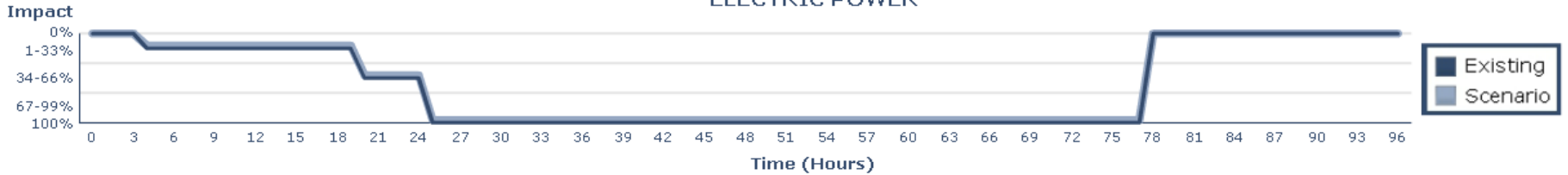
- Information collected on external dependencies
  - Use of the dependency
  - Primary source (provider information)
  - Contingency and/or priority plans
  - Backups
    - What type and what they support
    - How long will it last
    - Are there fueling agreements in place





- Overview
- Electric Power**
- Natural Gas
- Water
- Wastewater
- Communications
- Information Technology
- Transportation
- Critical Products

## ELECTRIC POWER



Is external electric power required for Facility core operations (e.g., produce key services/goods)?

No  Yes

If external electric service is lost (without considering any backup or alternative mode), how soon would the facility be severely impacted (hours):



Does the facility have an alternate or backup that can be used in case of loss of external source?

No  
 Yes

Does the facility have a backup generator?

No  
 Yes

Does the facility have Uninterrupted Power System (UPS)/Battery backup?

No  
 Yes

Duration of backup generation w/out refueling (hours):



Duration of UPS/Battery backup (hours):



Use of the UPS/Battery backup

- In addition to backup generator(s)
- To accommodate switch from external supply to backup generator(s)
- Sole backup for loss of external supply

Once external electric service is lost (and considering your backup or alternative mode), what percentage of normal business functions are lost or degraded:

- None
- 1-33%
- 34-66%
- 67-99%
- 100% (Offline)

Once external electric service is lost (without considering any backup or alternative mode), what percentage of normal business functions are lost or degraded:

- 1-33%
- 34-66%
- 67-99%
- 100% (Offline)

Are there external regulations/policies that mandate the facility shut down after loss of electric service including backup?

No  
 Yes

After how long? (hours)



Once external service is restored, how long would it take before full resumption of operations? (hours)



# Takeaways

- Common resilience themes for all infrastructure
- Focus on maintaining operations leads to strong continuity practices, backups and contingency plans
- Dependencies are a key part of resilience
  - How aware are the energy infrastructures of their dependencies?
  - Do they understand the impact of a loss of a key dependency?
  - Do they have contingency plans to mitigate against the loss?
  - Have they worked with their local providers and other customers to understand priorities?
- Understanding community/regional dynamics is critical to gaining a holistic viewpoint of resilience

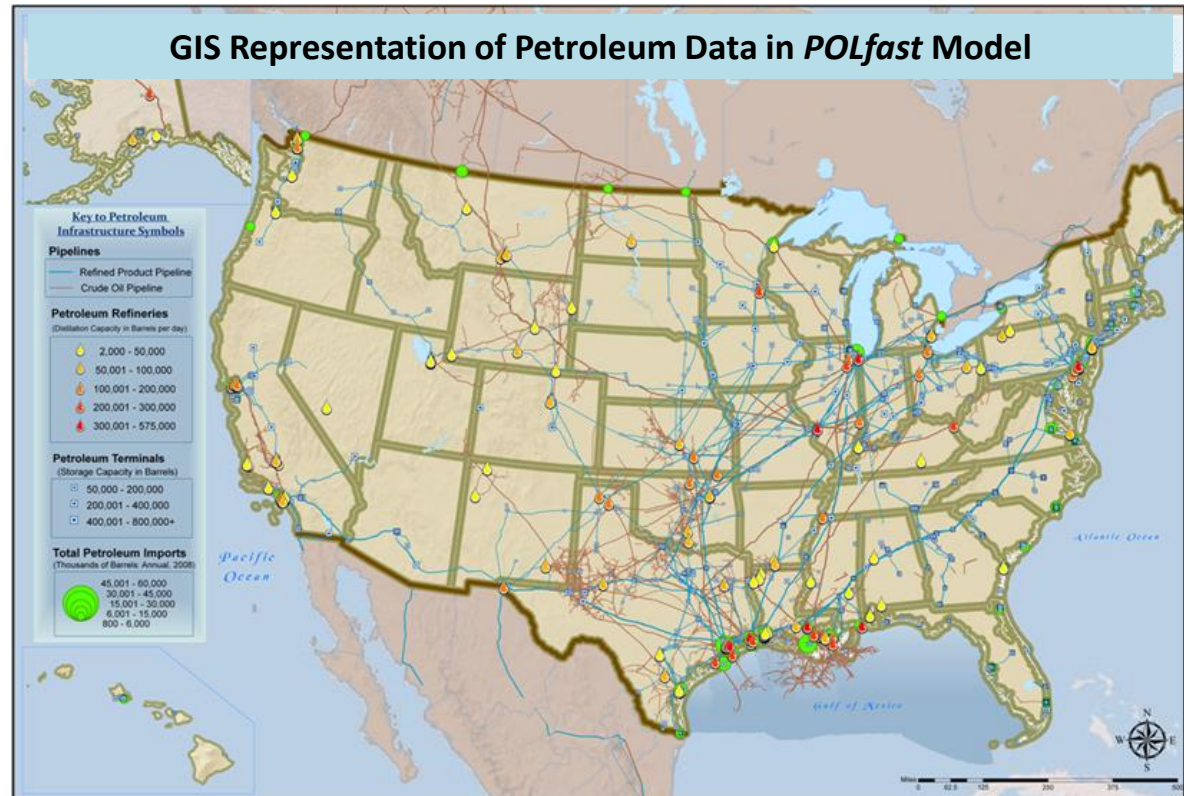


# BACKUPS



# POLfast: National Petroleum Model for Regional Flows

- Provides quick estimate of downstream impacts from disruption of:
  - Single or multiple facilities.
  - Inter-regional flows.
- National petroleum model:
  - Over 140 petroleum refineries.
  - 145 ports-of-entry.
  - Nearly 40 major crude and refined petroleum pipelines.
- Accounts for effects of mitigating measures such as:
  - Crude oil and refined product storage
  - Crude oil production wells
  - Spare pipeline and refinery capacity
  - Crude oil and refined product imports.



- Considers multiple refined products:

- Motor gasoline
- Diesel/distillate
- Jet fuel
- Residual fuel oil

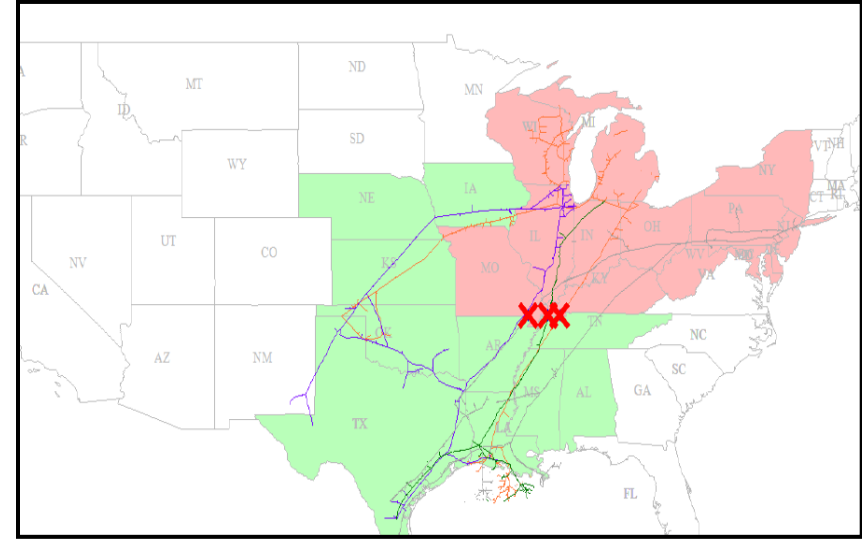
# EPfast: Model for Uncontrolled Islanding and Load Flow Analysis

- **Electric System Simulator.**
- **Impact analysis tool, not an optimization model:**
  - Linear model, employing DC load flow.
  - Powered by an efficient LINGO solver.
- Performs traditional load flow analysis, contingency studies, and islanding analysis:
  - Ability to track cascading line outages.
  - Ability to track successive island grid formation and re-simulate each island until stable supply-demand balance is reached.
  - Ability to estimate magnitude (MW loss) and spatial extent of power outages.
- Visualization capabilities:
  - User-friendly GUI.
  - Tabular and graphical output.
  - GIS output can be exported to any GIS viewer.



# NGfast: Model for Natural Gas Pipeline Breaks and Downstream Impacts

- **Linear, steady-state model provides a quick estimate of impacts on the downstream market of:**
  - Single or multiple pipeline breaks
  - Flow reduction problems
- **This national model includes:**
  - Over 80 interstate and other pipelines
  - Over 1,800 local distribution companies (LDCs)
  - Over 800 state border points
- **Compensated/uncompensated modes account for effects of mitigating measures such as:**
  - underground storage (UGS)
  - liquefied natural gas (LNG)
  - Natural gas production facilities
  - Spare pipeline capacity.
- **Graphical user interface (GUI) navigation uses “point-and-click” features, is superfast, and is easy to use**



- **Graphical and tabular HTML – formatted outputs**

- **Applications:**

- Exercise analysis
- Hurricane analysis
- Seismic analysis
- Incident support

For more information:

<http://www.dis.anl.gov/projects/ngfast.html>

