U.S. DEPARTMENT OF ENERGY | Office of Electricity Delivery and Energy Reliability

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# DOE Analytical Approach for Assessing Program Impacts

SMARTGRID.GOV
RECOVERY ACT SMART GRID PROGRAMS

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# A smart grid project can deploy assets in every area of the electricity grid.

| Areas of Smart Grid Asset Deployment | | | | |
|---|---|---|---|---|
| Customer Systems | Advance Metering Infrastructure | Electric Distribution Systems | Electric Transmission Systems | Generation and Storage |
|  |  |  |  |  |
| • Displays<br>• Portals<br>• Energy management<br>• Direct load controls | • Smart meters<br>• Data management<br>• Back office integration | • Switches<br>• Feeder optimization<br>• Equipment monitoring | • Wide area monitoring and visualization<br>• Phasor measurement<br>• Grid optimization | • Distributed generation<br>• Renewables<br>• Advanced batteries, flywheels, etc. |

# Build and Impact Metrics are being used to assess asset deployment and project benefits respectively.

## Build Metrics → Asset Deployment

- Monetary Investments
- Electricity Infrastructure Assets
- Policies and Programs
- Marketplace Innovation

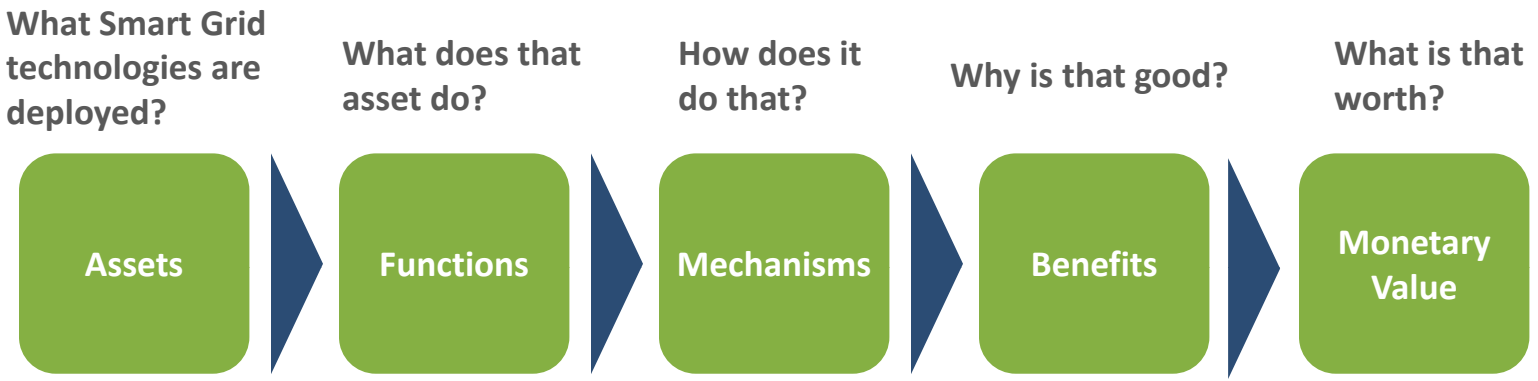
## Impact Metrics → Benefits

- Metrics for economics, reliability, environmental and oil-security impacts
- Different metrics for transmission, distribution, and AMI/customer system projects

# Build metrics will be used to answer the following questions:

| Key Questions to Address |
| --- |
| **1. What was purchased, built, and deployed?**<br>• # of assets or programs<br>• Type of assets or programs<br>**2. How much did it cost?**<br>• Cost segmentation: assets, labor , and specific asset type<br>**3. Where was it installed?**<br>• NERC Region, State, or recipient locations<br>**4. How much of the system was affected?**<br>• % of system, % of customers, % of load<br>**5. What does it do?**<br>• Characteristics of assets or programs: Intended function or use of assets |

# The framework below will be applied to assess benefits in several key focus areas.



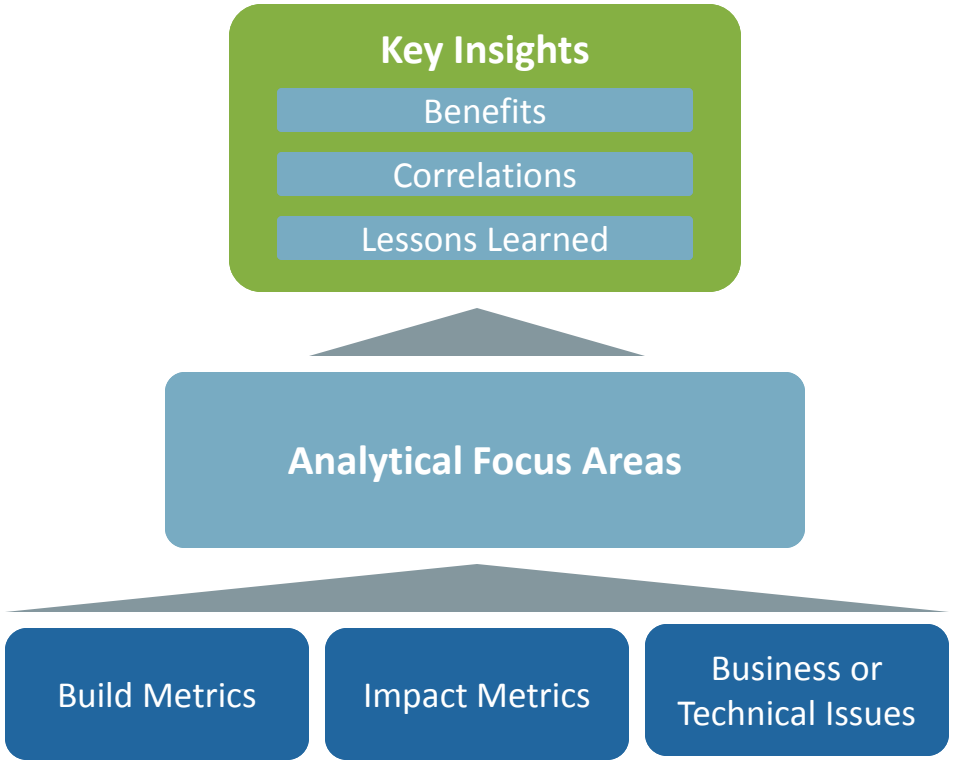

*Example*

| Example | | | | | |
|---|---|---|---|---|---|
| | • Capacitor controls<br>• Distribution Management System | Automatic Voltage and VAR Control | Improves feeder voltage regulation | Reduced feeder losses worth $60 per MWh | $6000 |

## Analytical focus areas allow exploration of key build and impact metrics in collaboration with project teams, and communication of key insights.

Analytical focus areas are designed to:

- ***Explore*** Build and Impact metrics that may not be consistently or clearly reported
- ***Dig deeper*** into the underlying correlations between assets and impacts
- Analyze issues that are not well documented or presented with the standard reported metrics, that require ***qualitative interactions*** with projects
- ***Communicate the key insights*** related to the impacts of DOE's Smart Grid programs



# Impact Metrics will be analyzed in 7 analytical focus areas.

**AMI & Customer Systems**

A1- Peak Demand and Electricity Usage

A2 -Meter Operations and Maintenance Cost Savings

**Distribution Systems**

D1 - Distribution System Reliability

D2 - Distribution System Energy Efficiency Improvements related to 'Line Losses'

D3 - Distribution Operations and Maintenance Cost Savings

**Transmission**

T1 – Transmission Reliability and Applications of Synchrophasor Technology

**Consumer Behavior**

CB1- Understand the Impact of AMI and Time-based Rate Programs on Consumer Behavior

**Impact Metrics contain confidential information so the analysis will be conducted at an aggregated level.**

# This "AMI & Customer Systems" analytical focus area will assess the impact of smart grid technologies on the reduction in peak and electricity consumption.

**Project Type: AMI & Customer Systems**

Summary Description

*Objective:* Determine the changes in peak load and electricity usage achieved and understand the contribution of different technologies and pricing programs. Assess overall reduction in customer bills resulting from programs. Identify the key capabilities of the technologies and customer programs while determining next steps for advancement along the maturity curve.

Key Questions

1. How much peak reduction was achieved?
2. What contributed to the reduction?
3. What was the benefit of the peak reduction?
4. How much did electricity usage decrease?
5. What contributed to the electricity usage reduction?
6. How much was the customers bill affected?

**Reduced Peak and Electricity Usage**

Analytical Scope and Approach

- Collaborate with projects to treat load and electricity cost data for economic, weather, and other effects
- Collaborate with system operators to identify weather and operational conditions which affected demand and wholesale electricity prices
- Examine the non-coincident peak load during the top 100 hours to determine changes over time
- Correlate peak load, electricity consumption and cost changes to the technologies and pricing program combinations implemented by the projects:
  - AMI and Time-based rate programs, e.g. CPP, RTP
  - Information feedback and enabling technology comparisons
  - AMI, existing rates and information feedback
  - Direct Load Control programs

Key Impact Metrics Analyzed

- Peak load and mix (amount of load that is controllable)
- Hourly and monthly customer electricity usage
- Hourly and monthly customer electricity costs
- Average customer bills

# This "AMI & Customer Systems" focus area will examine the impact of smart grid technologies on meter operations and maintenance cost savings.

**Project Type: AMI**

Summary Description

*Objective:* Determine the amount of operations and maintenance (O&M) cost savings achieved by AMI projects and understand the contribution of different technologies and meter functionality. Identify key capabilities of the technology and next steps for advancement along the maturity curve.

Key Questions

1. How much are Meter O&M costs reduced?
2. What contributed to the O&M cost reduction?
3. What is the environmental benefit of the O&M savings?

**Meter Operations & Maintenance Cost Savings**

Analytical Scope and Approach

- Collaborate with projects to treat cost data for economic and other effects
- Correlate changes in meter O&M cost to the combinations of AMI smart meter functionality implemented by the projects:
  - Automated Meter Reading
  - Remote Connection/Disconnection
  - Outage and Restoration Notification
  - Power Quality Monitoring
  - Tamper Detection and Notification
- Identify the underlying causes of the O&M cost reduction
  - Reduced labor hours
  - Reduced vehicle cost
  - Other

Key Impact Metrics Analyzed

- Meter Operations Costs
- Meter Vehicle Miles
- Avoided Truck Rolls
- Outage Restoration Costs

# This "Distribution Systems" analytical focus area will examine the impact of smart grid technologies on the frequency and duration of outages.

**Project Type: Distribution**

**Reduction in the Frequency and Duration of Outages**

Summary Description

*Objective:* Determine the reduction in the frequency and duration of outages and other reliability improvements achieved by Distribution Automation (DA) projects and understand the contribution of different technologies and functionality. Identify key capabilities of the technology and next steps for advancement along the maturity curve.

Key Questions

1. How much does DA reduce the frequency and duration of outages?
2. How much does DA improve reliability?
3. What contributed to the reliability improvements?
4. What is the economic benefit of the reliability improvements?

Analytical Scope and Approach

- Collaborate with projects to treat reliability data for weather and major event effects
- Correlate changes in reliability data to the combinations of DA technologies and functionality implemented by the projects (excluding major events):
  - Monitoring Devices (fault indicators, monitors)
  - Remotely Operated Devices (automated switches)
  - Automated Devices (reclosers employing FLISR)
- Collaborate with projects after major events to understand the changes in reliability and restoration data resulting from the implementation of DA
- Estimate the economic value of changes in reliability achieved by the projects by utilizing existing value of service studies

Key Impact Metrics Analyzed

- SAIFI / SAIDI/ CAIDI
- Outage Response Time
- Major Event Information
- Equipment Failure Incidents

# This "Distribution Systems" analytical focus area will assess improvements in the efficiency of electricity delivery resulting from smart grid technologies.

**Project Type: Distribution**

**Improvements in the Efficiency of Electricity Delivery (Line Losses)**

Summary Description

*Objective:* Determine the improvement in the efficiency of electricity delivery (line losses) achieved by DA projects and understand the contribution of different technologies. Identify the key capabilities of technologies while determining the next steps for advancement along the maturity curve

Key Questions

1. How much does DA reduce line losses?
2. What DA assets contributed to the line loss reduction?
3. What is the economic and environmental benefit of the reduction?

Analytical Scope and Approach

- Collaborate with projects to identify calculation and modeling methods to determine line losses
- Treat energy and load data for weather, economic and other effects
- Correlate changes in line loss data to the combinations of DA technologies and functionality implemented by the projects:
  - Automated Capacitors
  - Automated Regulators
  - Voltage/VAR Optimization functionality
- Estimate the economic value of energy savings resulting from the reduction in line losses by utilizing wholesale electricity prices listed by system operators

Key Impact Metrics Analyzed

- Distribution Feeder Load (average/ hourly)
- Distribution Losses (as a % load)
- Distribution Losses (MWhs)
- Distribution Power Factor

# This "Distribution Systems" analytical focus area will examine operations and maintenance cost savings resulting from smart grid technologies.

## Project Type: Distribution

### Summary Description

*Objective*: Determine the amount of operations and maintenance (O&M) cost savings achieved by DA projects and understand the contribution of different technologies and asset functionality. Identify key capabilities of the technology and next steps for advancement along the maturity curve.

### Key Questions

1. How much are O&M costs reduced?
2. What assets and functions contributed to the O&M cost reduction?
3. What is the environmental benefit of the O&M Savings?

## Operations & Maintenance Cost Savings

### Analytical Scope and Approach

- Collaborate with projects to treat cost data for economic and other effects
- Correlate changes in Distribution O&M cost to the combinations of DA technology and corresponding functionality implemented by the projects:
  - Monitoring Devices
  - Remotely Operated Devices
  - Automated Devices
- Characterize the operational impact of DA technology on distribution operations and identify the underlying causes of the O&M cost reduction
  - Reduced labor hours
  - Reduced vehicle cost
  - Other

### Key Impact Metrics Analyzed

- Operations Costs
- Maintenance Costs
- Avoided Truck Rolls
- Vehicle Miles

# This "Transmission" analytical focus area will examine reliability improvements and the application of synchrophasor technology.

**Project Type: Transmission**

Summary Description

*Objective:* Understand the nature and scope of synchrophasor technology deployment and how these new tools can be used to improve grid reliability and operations. Identify key capabilities of the technology and next steps for advancement along the maturity curve.

Key Questions

1. How much of the transmission system is visible with synchrophasor technology?
2. How is the technology changing control room operations?
3. How is reliability and grid security being improved as a result?

**Transmission Reliability and Applications of Synchrophasor Technology**

Analytical Scope and Approach

- Track the rate of deployment of PMUs, PDCs and Communications systems to determine the portion of the transmission system that can be "seen"
- Identify the type of advanced applications that have been deployed and how operators and planners are using them
- Track the performance of synchrophasor technologies including availability and reliability
- Determine which applications are providing detection system events and potential mitigation of their effects
- Estimate the potential magnitude of reliability benefits derived from synchrophasor information
- Characterize the operational impact of synchrophasor technology on grid operations and planning, and estimate the operational efficiency benefits
- Identify key next steps and RD&D initiatives for synchrophasor technology

Key Impact Metrics Analyzed

- Transmission Events
  - Loss of Load
  - Energy Emergency
- Overload Incidents

# This "Consumer Behavior" analytical focus area will examine the impact of AMI, enabling technology and time-based rate programs on consumers.

**Project Type: Consumer Behavior**

**Understand the Impact of AMI and Time-based Rates on Consumers**

### Summary Description

*Objective:* To advance the electricity industry's understanding of consumer behavior by addressing unanswered issues and questions surrounding the acceptance of and response to time-based rates, automation technology, and information technology with highly rigorous experimental methods

### Key Questions

1. How does customer acceptance of and response to time-based rates differ across market segments?
2. How does customer acceptance of and response to time-based rates differ when coupled with information and/or control technology?

### Analytical Scope and Approach

- Apply highly rigorous randomized controlled experimental designs to achieve highly precise and credible estimates of the change in consumer behavior
- Form technical advisory groups (TAGs) to provide technical assistance to each recipient and ensure these exacting standards are met
- Analyze hourly customer electricity consumption data to estimate the impacts of the exposure to time-based rates, automation technology and/or information technology using the following methods:
  - Electricity Consumption Impacts Estimation
    - Difference-in-difference
    - ANOVA and ANCOVA
    - Panel regressions
    - Individual customer regressions
  - Electricity Demand Model Estimation

### Key Impact Metrics Analyzed

- System-coincident peak load
- Hourly and monthly customer electricity usage
- Own-price, cross-price, daily-price and substitution elasticities

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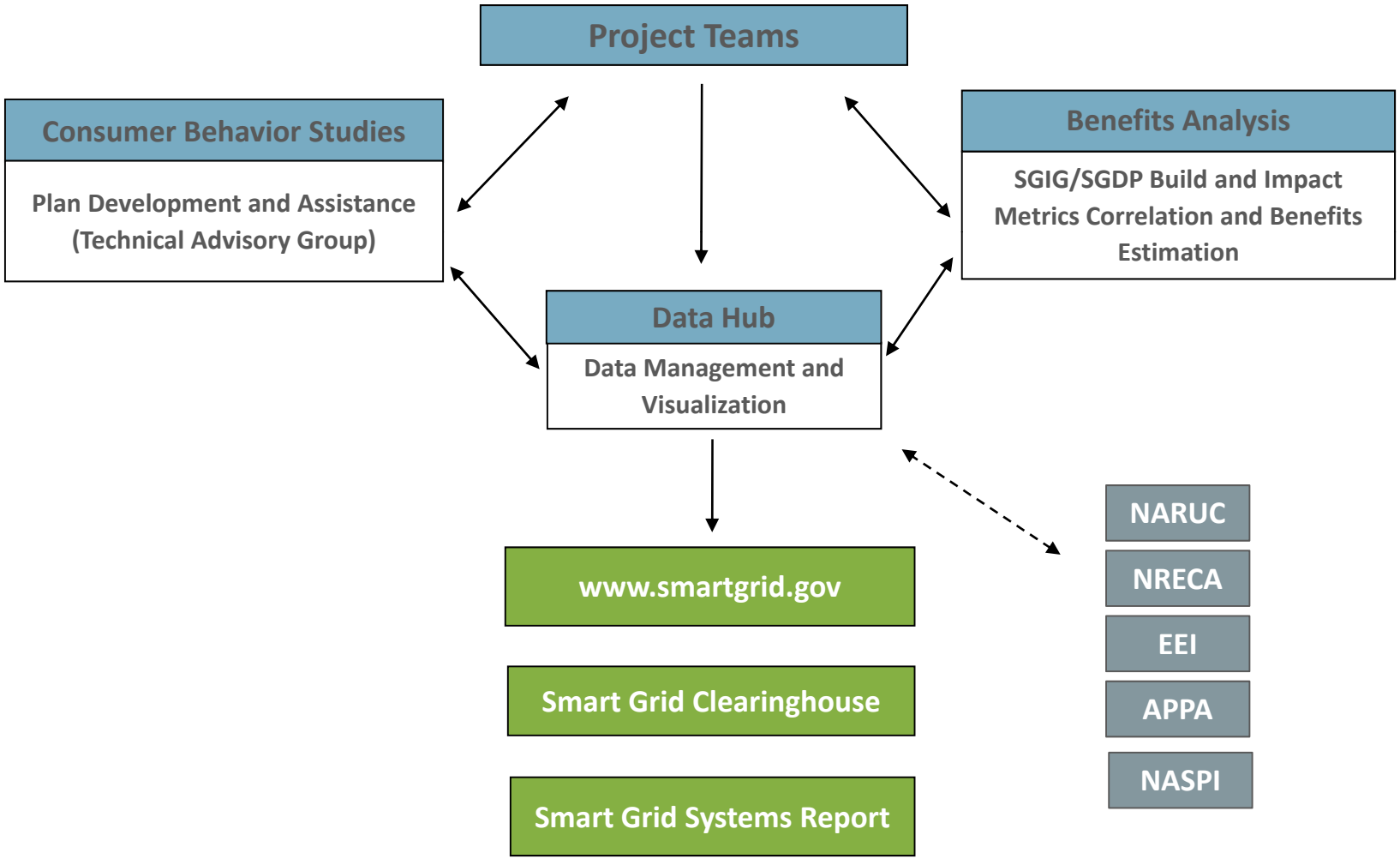
# DOE is working with grant recipients to document their metrics and benefits reporting plans and, for some recipients, consumer behavior study plans.

| | |
|---|---|
| Metrics and Benefits Reporting Plans | • Required for all Smart Grid Investment Grant (SGIG) and Smart Grid Demonstration (SGD) recipients<br>• Documents Build and Impact Metrics to be Reported |
| Consumer Behavior Study Plans | • Approximately 10 SGIG recipients performing rigorous consumer behavior studies<br>• Documents time-based rate program design and reporting plans<br>• Describe experimental design study |
| Technology Performance Reporting Plans | • Required for all SGD recipients<br>• Documents reporting objectives for demonstration project performance results |

# Data reporting and analysis is being managed by the Metrics and Benefits team, which is led by DOE staff.



# Reporting and analysis of deployment and performance will occur on an ongoing basis throughout the program, and results shared on Smartgrid.gov.

## Smart Grid Investment Grant Program

| | |
|---|---|
| Build Metrics | • Quarterly reporting by recipients<br>• By project and aggregated for the program |
| Impact Metrics | • Semi-annual reporting by recipients<br>• Aggregated results |
| Meta-Analysis of Performance Impacts | • Analytical focus areas<br>• Insight for use in business case analysis |
| Consumer Behavior Studies | • Evaluation Reports (per project)<br>• Meta-Analysis of consumer behavior studies |

## Smart Grid Demonstration Program

| | |
|---|---|
| Build Metrics | • Quarterly reporting by recipients<br>• By project and aggregated for program |
| Technology Performance Reports | • Interim and final reports on technology performance<br>• By project |