National Renewable Energy Laboratory
Innovation for Our Energy Future

AAPA
Environmental Committee Meeting

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Agenda

- Who is NREL?
- NAVY & Disaster Recovery Experience
- Areas of assistance
  - Resiliency
  - Energy Efficiency
  - On Site Generation
  - Transportation
  - Microgrids
  - Financing/Funding Options
- Questions?

NREL

- **National Renewable Energy Laboratory (NREL)**
- Owned by the Department of Energy (DOE)
- Only US National Laboratory Dedicated Solely to Energy Efficiency and Renewable Energy
- ~1600 Employees & Contactors
- Operated by the Alliance for Sustainable Energy

Scope of Mission

Energy Efficiency

Residential

- Buildings
- Commercial Buildings
- Personal and Commercial Vehicles

Renewable Energy

Solar

- Wind and Water
- Biomass
- Hydrogen
- Geothermal

Systems Integration

Grid

- Infrastructure
- Distributed Energy Interconnection
- Battery and Thermal Storage
- Transportation

Market Focus

International

- Private Industry
- Federal Agencies
- Defense Dept.
- State/Local Govt.

US Navy Experience

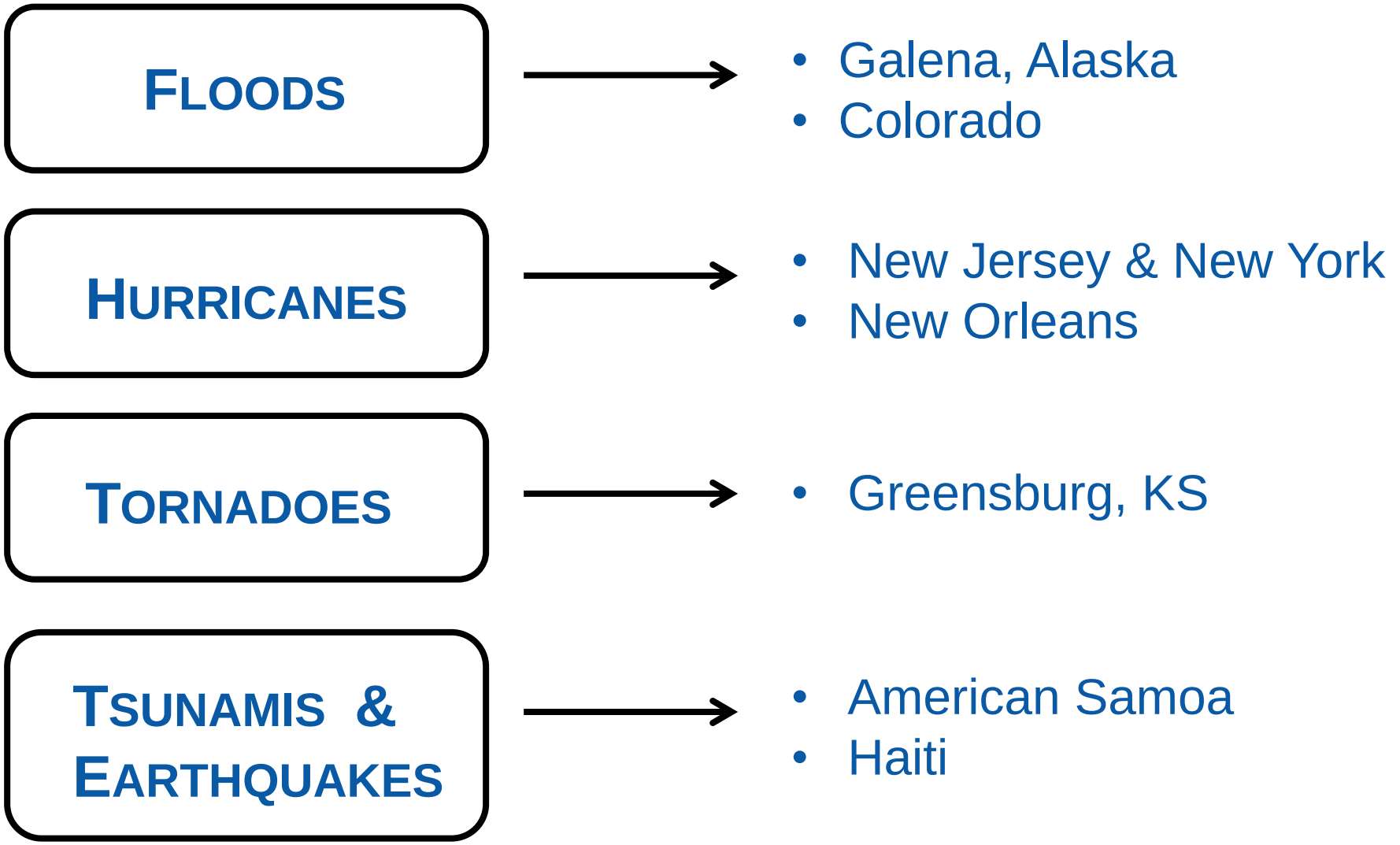
- Analyzed Renewable Energy (RE) and Energy Efficiency (EE) project opportunities for over 70 installations worldwide

Areas of Biggest Assistance:

- Net Zero Energy Installations
  - Deep Energy Efficiency Audits/Installation work
  - Demand Reduction
  - On-site generation (Thermal, RE)
  - Identification of mission enhancing and risk reduction energy project opportunities

    - Most of work is classified

Disaster Recovery Experience



Resiliency

- NREL's disaster resilience program works towards identifying solutions to create robust, flexible facilities and sites
- Broad spectrum of options
  - Cursory Review identifying areas of weakness
  - Coordination with NOAA to create simulated hurricane paths/strengths with likely damage for resiliency focus

Energy Efficiency Assessments

Overview: Detailed site audits focused on energy efficiency opportunities

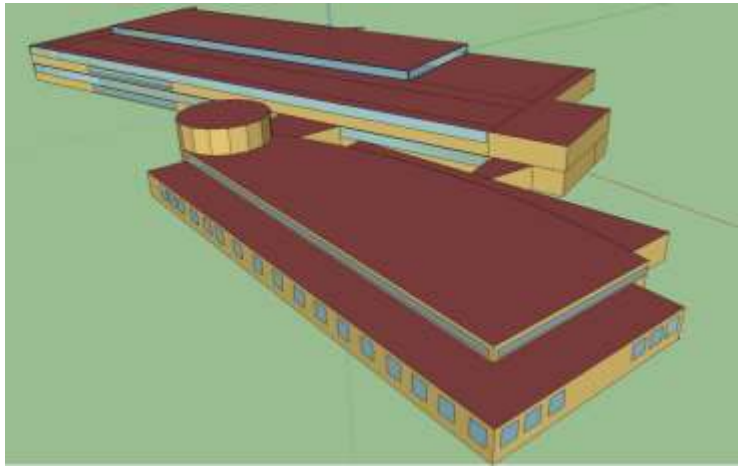
- Building energy audits
- Energy Modeling
- Prioritization of ECM (Energy Conservation Measures) opportunities
- Deep retrofit analysis

New Directions:

- Improved approaches to audit process (remote audits, on-going audits, modular modeling)
- Assist in prioritization strategies
- Combined EE/RE analysis (REopt)
- Developing world assistance
- Demonstration of deep retrofit modeling in OpenStudio

Core Capabilities:

- Technical understanding of buildings systems and their interactions
- Field experience with a wide array of building systems
- Spot metering and M&V expertise



Credit: Caleb Rockenbaugh NREL

REopt Planning Tool

- Planning tool to evaluate RE, EE, microgrid, and operational energy opportunities
- Recommends a mix of technologies and an operating strategy that meets client goals at minimum lifecycle cost
  - Considers interactions between multiple technologies
  - Estimates costs and energy savings

- Has been used to assess opportunities at ~800 sites
- Technologies currently modeled:
  - PV
  - Wind
  - Solar hot water
  - Solar vent preheat
  - Biomass
  - Waste to energy
  - Landfill gas
  - Diesel and natural gas generators
  - Battery storage






- Robust and adaptable to meet client goals

On Site Generation

- Renewable Energy/Natural Gas Assessments
- Thermal/Electrical/Storage Analysis
- Market Opportunities (Energy/Capacity Sales)
- Conversion from ship based to land based power
- Load Aggregation
- Benefits
  - Lower Energy Costs
  - Improved Resiliency
  - Lower Emissions

Transportation

Accelerate adoption of high-performance, low-emission, energy efficient passenger & freight vehicles

- Electric, hybrid, fuel cell, and conventional vehicle technologies
- Biofuels, hydrogen, natural gas, propane
- Charging and fueling infrastructure
- Battery storage

NREL / SCAQMD Port Drayage Projects

Zero Emissions Cargo Transport (ZECT)

- Objectives
  - Develop and demonstrate zero emission drayage truck technologies in real world cargo transport operations – Port of LA/Long Beach
- NREL funded by DOE to collect vehicle data and evaluate performance

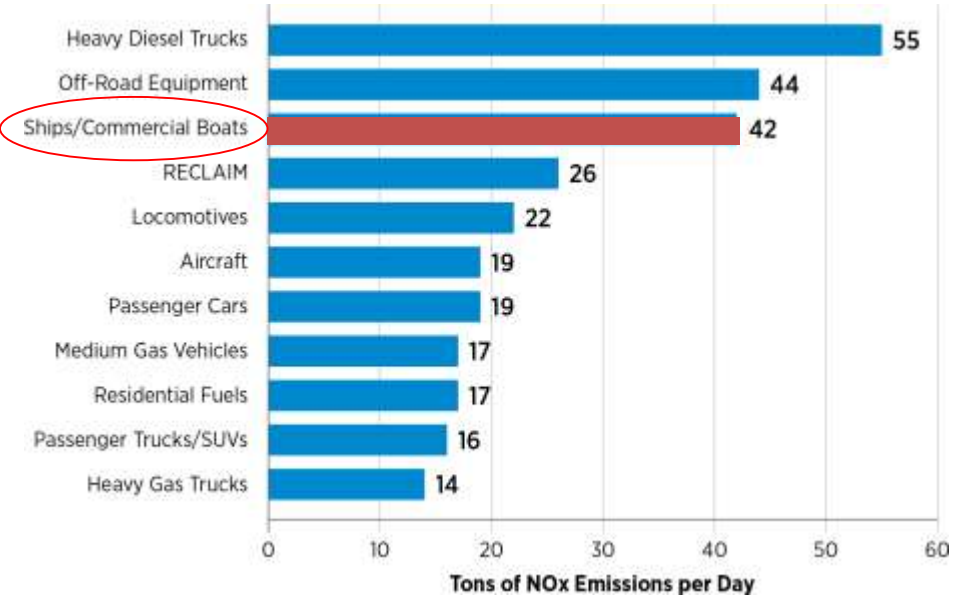
SCAQMD - NREL FleetDNA Roadmap

- Objectives – *apply NREL FleetDNA approach to:*
  - match powertrains and advanced technology with observed duty cycles of medium- and heavy-duty trucks.
  - provide information to enable intelligent deployment of advanced technology to maximize fuel economy and emissions reductions in the South Coast air basin
  - Currently collecting vehicle duty-cycle data on ***port drayage***, transfer trucks, and delivery vehicles

CEC NGV Technology Roadmap

Objective: Inform natural gas vehicle R&D investment decisions made by the California Energy Commission (CEC) and stakeholders to promote increased ratepayer benefits

Projected Sources of NOx Emissions in South Coast Air Basin by 2023 (tons/day)



Source: California Air Resources Board

NREL is working with CEC to updates previous Roadmap to:

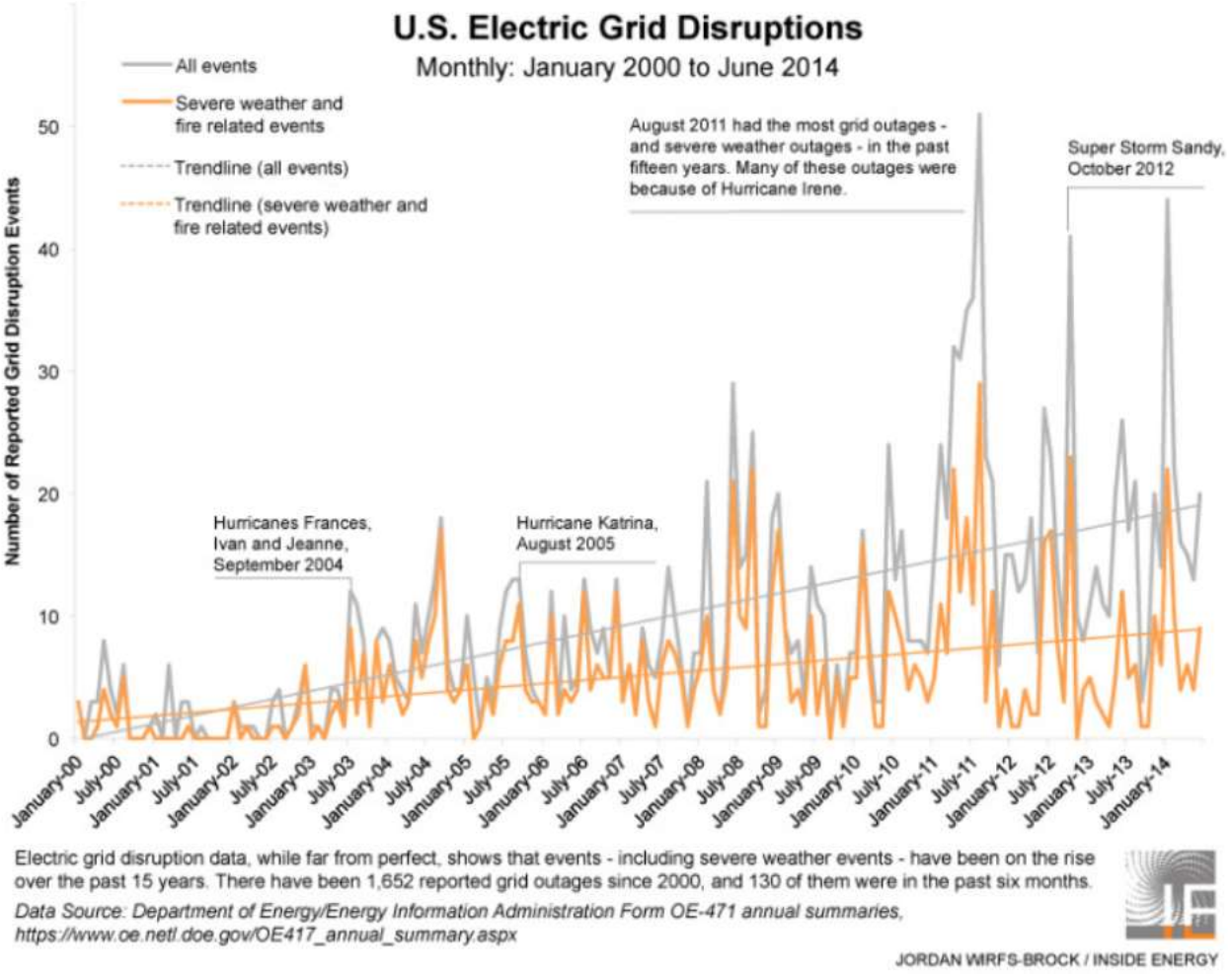
- Identify emerging opportunities
- Identify fundamental changes in the NGV market and associated technologies

Marine, rail, and other high horsepower technologies present a sizable opportunity for natural gas

- Marine emissions are responsible for the 3rd largest share of NOx emissions in the South Coast Basin

Energy Service Disruptions

* Climate Central (2014)



- Outages ⬆
  - Weather
  - Physical
  - Cyber

"the number of minutes customers are without power is increasing 5% to 10% every year" LBNL and Stanford University (August 2015)

Microgrid Definition & Benefits

A coordinated energy and electrical distribution system with dispatchable resources capable of both grid interactive and autonomous operation that includes:

- Multiple Distributed Energy Resources—traditional diesel gensets to renewable energy and storage options
- Sophisticated Monitoring and Controls—including load shedding, generation curtailment and energy management

A microgrid can:

- Isolate itself from the grid when utility disturbances occur, and reconnect when the grid is stable
- Provide power to essential loads during extended grid outages
- Incorporate renewables to extend the fuel supply of conventional generators and provide a power supply for continued operation of selected loads
- Improve overall system reliability and power quality

Microgrid Background

Need for a smarter grid

- Utility monitoring and control facilities
- Bidirectional information flow
- User-level decisions
- Economic benefits

Need for Energy Resiliency

- Enhance monitoring capabilities
- Protection from physical/cyber events
- Centralized vs. distributed control boundaries
- Develop survivable systems

➢ **Value of Electrical Energy Security**

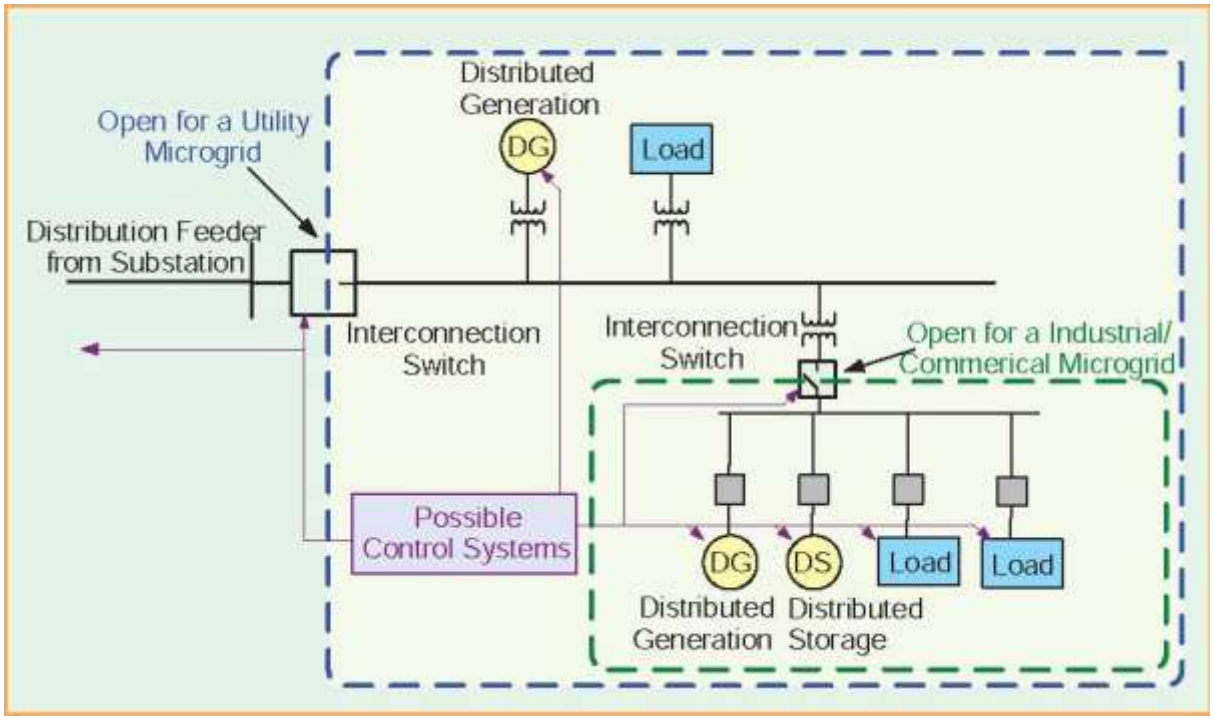
Microgrid Definition

Types of microgrids:

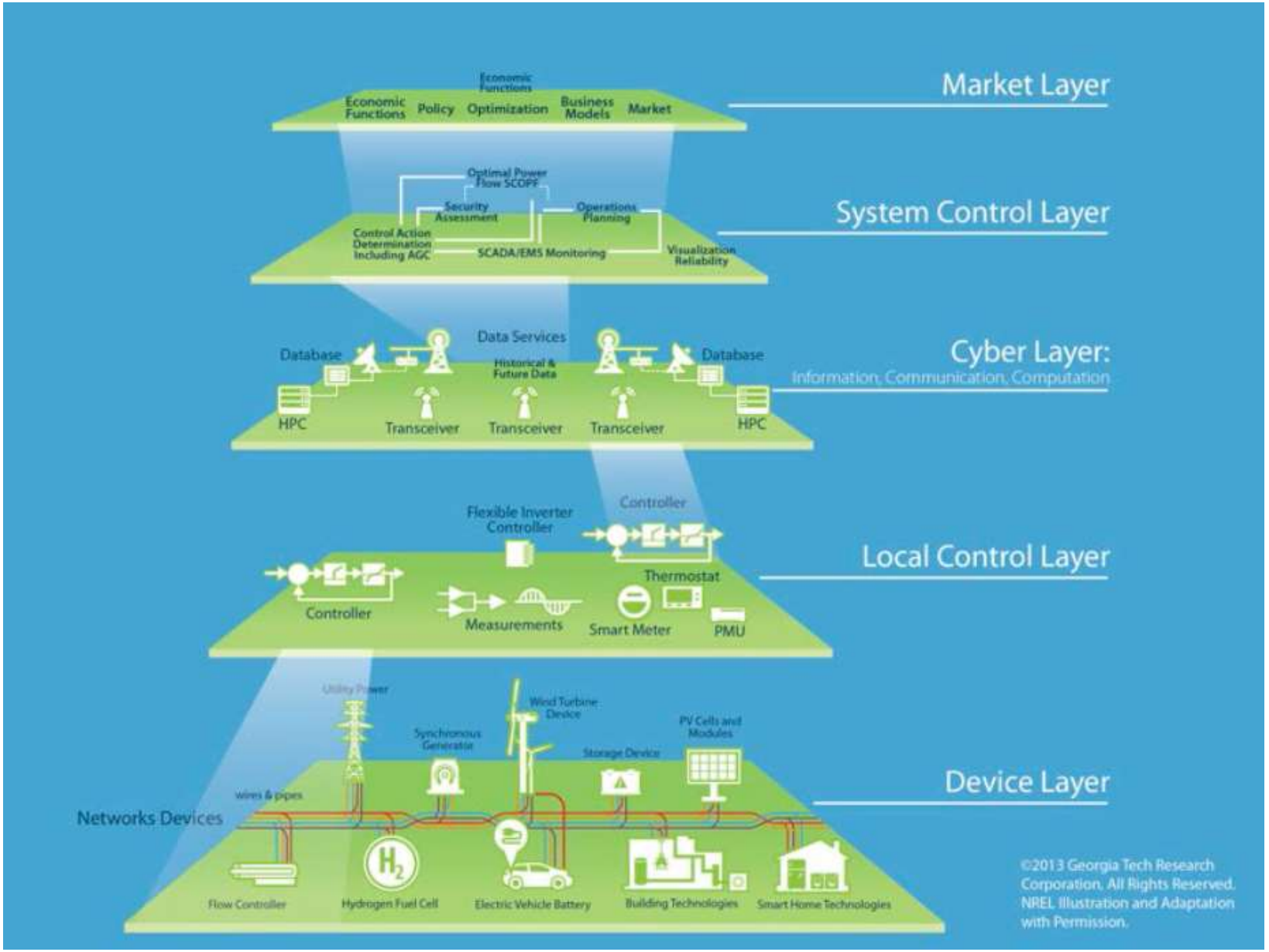
- Building => Campus/community => Regional/small city

Modern DG

- Increasing levels of renewable energy
- Improving quality/reliability of power



Future Energy Systems Architecture



Financing Options

On-Site Renewable Energy Project

- Federal/State
  - Grants
  - Rebates
- Purchased Power Agreements (PPAs)
- Lease/Purchase Model

➢ Evaluation dependent upon
  - Current Energy Supplier/Market Conditions
  - Net Metering/Feed in Tariffs credits
  - Interconnection analysis

Funding Options

- Direct
- State/Local Governments/Agencies
- Federal
  - Department of Transportation/Maritime Administration
  - Department of Commerce
  - Department of Homeland Security
- Outage costs
  - Lost time wages for workers
  - Local/US productivity
- Emission Reduction
  - Metro/Non-Attainment Area
  - Credit for future emission reduction efforts

Thank You and Questions?

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Long Term Solar Pricing Forecasts