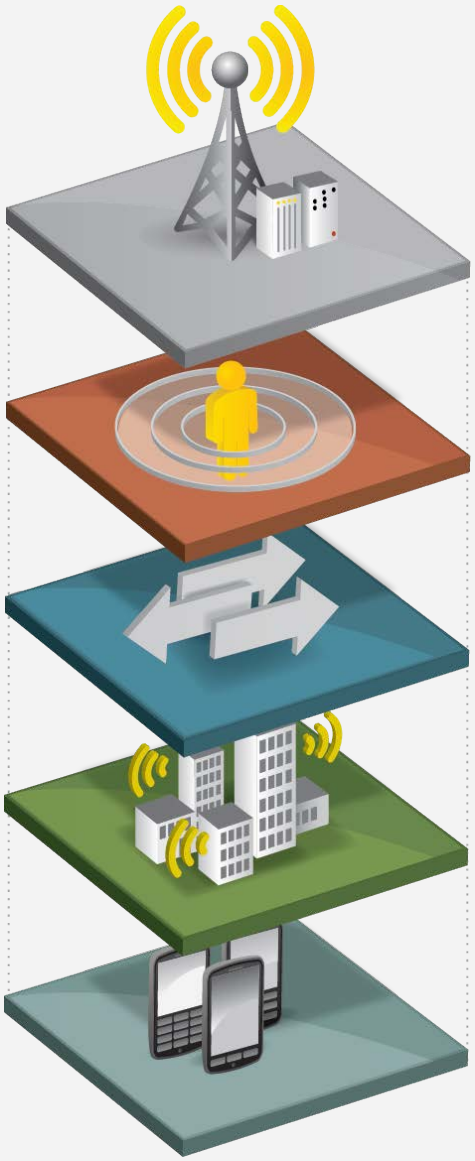

Briefing to the Hydrogen and Fuel Cell Technical Advisory Committee

Kevin Kenny

Network Engineer – Power Standards

kevin.p.kenny@sprint.com

(703)592-8272

April 24, 2013

Part I: Update on Sprint's ARRA Project

"Use of 72-Hour Hydrogen PEM Fuel Cell Systems to Support Emergency Communications"

Project supports job retention and creation in several industries/businesses:

- ✓ *HFCs manufactured/assembled by two vendors with direct manufacturing as well as indirect job market impacts to the various material/component suppliers involved in the supply chain*
- ✓ *Fueling partner to develop and provide at least 330 MPHSS cabinets and 5,280 Hydrogen Tanks (11BC615)*
- ✓ *Staffing to support hydrogen production, distribution logistics, and technical field support in multiple geographic regions*
- ✓ *Two A&E firms retained to provide engineering, site acquisition, project management, and construction management*
- ✓ *Local tradesmen (construction, electrical) to complete on-site installation, commissioning, and support services*
- ✓ *Ericsson project management services provided to support lease modification, site acquisition, material procurement, project coordination, and Sprint specific requirements for data basing, implementation, and network integration*
- ✓ *Sprint will provide overall project supervision, financial governance, planning direction, incentive management, and all project performance and operational data reporting per contractual requirements*

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Relevance to DOE Goals

Expands installed Sprint fuel cell base from Southern US to Northeast and west coast regions, thus introducing HFC technology to new areas

- *Project more than doubles the number of HFCs deployed in Sprint's original field trial (237 units)*
- *Enables AHJ Permitting officials, trained during DOE-sponsored, Sprint-supported "Hydrogen Siting / Permitting Workshops" (held in both CA and NJ - metro NY) to put their knowledge to work evaluating this new technology in context with Sprint's proposed installations and associated permit applications*
- *Supports expansion of fueling project partner fleet to support off-road remote refueling applications, opening up a new market to hydrogen fueling previously accessible only to conventional fossil fueling trucks*
- *Provides a competitive green alternative providing operational parity to diesel generators in providing cell site backup power*
- *Demonstrates to the telecom industry and other industries/commercial entities the economic and operational viability of PEM Fuel Cells in lieu of incumbent backup power technologies*

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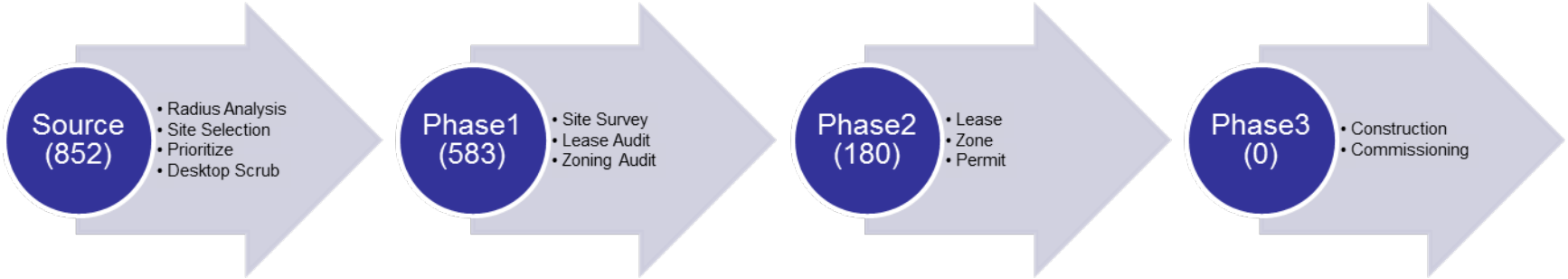
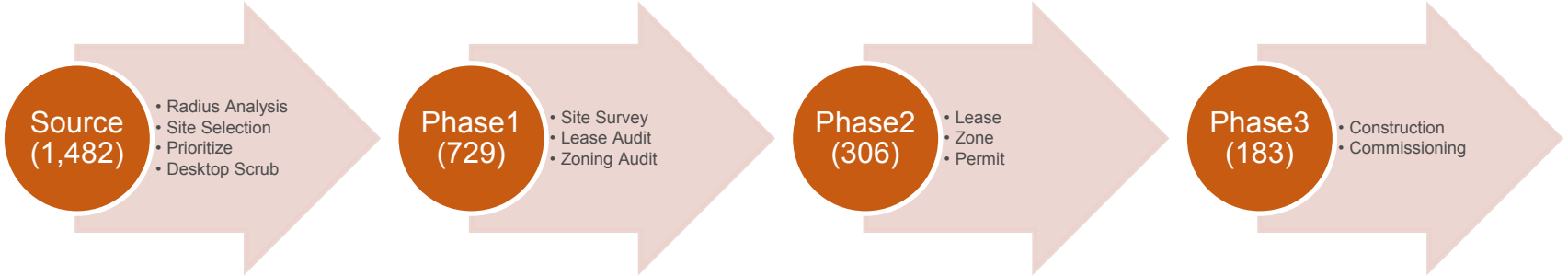
Approach - Site Lifecycle

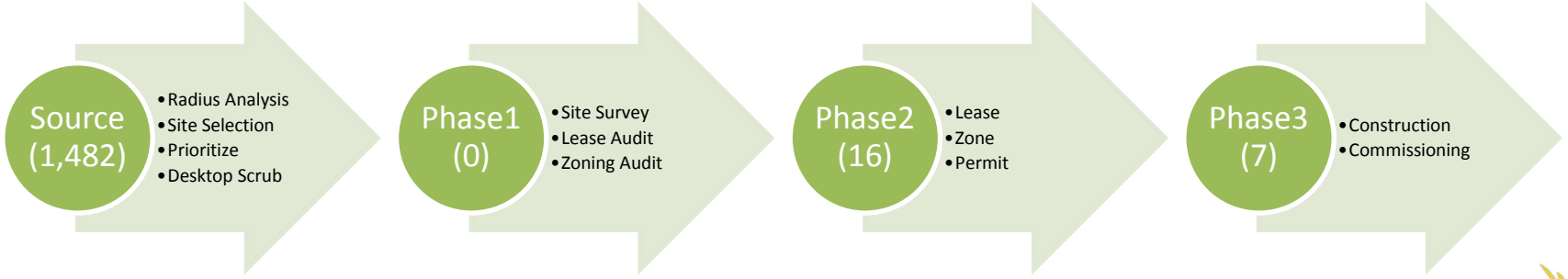
2011 Targets (As presented at 2011 ARRA AMR) – EOY11 Total New Sites = 169



2012 Targets (As presented at 2012 ARRA AMR) – EOY12 Total New Sites = 245



2013 Targets (2013 ARRA AMR) – EOQ12013 Total New Sites = 257. Only 3 to go!



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Approach - Source

- *Identify initial candidate pool of sites to be considered for HFC deployment which support specific types of "Critical Infrastructure" traffic. (Complete)*
- *Trim site list to account for the removal of sites with landlords not receptive to HFC installations (seen as a competitive threat to "premium" services offered by the landlord). (Complete)*
- *Ensure site mix includes both ground based and rooftop deployments – required to support both internal design criteria, as well as demonstrate the ability of the HFC to be utilized in various physical environments. (Largely complete. Rooftops avoided due to installation cost premium ~ $65k).*
- *Secure training on HFC operation / installation / commissioning for A&E vendors. (Complete)*
- *Develop Excel spreadsheet which is to be populated with data collected during the Phase 1 Site Survey. (Complete)*
- *Define HFC operational data collection arrangement to be used to gather and report HFC system performance information. (Complete)*
- *Establish Master Construction Services Agreement with potential installation partners to support Phases 2 and 3 of deployment effort (Complete)*
- *Ensure Hydrogen Storage Solution (HSS) selected can support 72-hour runtime requirement for site specific power load; can be refilled on-site while HFC is either in operation or in standby; and can be fit out with a standardized, vendor specific, External Fuel Control Module. (Complete)*

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Approach - Phase 1

- *This project has been organized into a three (3) phase approach: Site Survey, Pre-Construction (through Notice to Proceed), and Installation/Commissioning/Project Closure.*
  - *Phase 1: Site Survey. 100% Complete*
    - ✓ *Each candidate location shall be visited by the assigned A&E to document the site as detailed in the Site Survey Package (xls format).*
    - ✓ *Prioritized candidate list for each impacted market will be evaluated until the market deployment target is reached.*
    - ✓ *GO / NO-GO criteria for each site includes:*
      - *Site accessible by hydrogen refueling vehicle.*
      - *Space available <u>within</u> the existing compound to support equipment placement and code required setbacks.*
      - *Estimated Phase 2 / 3 costs are within budgeted amount.*
      - *Lease cost increase, if required, is within Sprint pre-determined OPEX cap.*
    - *The Final Site List will be assembled based upon information collected and sketches provided in the Phase 1 Site Survey Packages.*

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Approach - Phase 2

Phase 2: Pre-Construction (through Notice to Proceed). 100% (N) / 100% of pool (R) Complete

- *Site acquisition – fully executed lease amendment, if required.*
- *Secure all required permits (building, electrical, mechanical, or others required by AHJ).*
- *Zoning approval.*
- *NEPA approval (Secured NEPA Categorical Exclusion on 05/19/2011).*
- *Complete all required engineering drawings.*

✓ *Order major material (HFC and MPHSS).*

✓ *GO / NO-GO criteria for each site includes:*

  - *Lease amendment is fully executed or permission to proceed is provided by landlord.*
  - *All necessary permits have been secured..*
  - *Zoning approved.*
  - *NEPA approved.*
  - *All major material has been received at staging facility, or firm scheduled delivery date has been secured from the vendor.*
  - *NTP has been loaded in Sprint system.*

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Approach - Phase 3

- *Phase 3: Installation/Commissioning/Project Closure. 99% (N) or 100% of pool (R) Complete*
  - ✓ *Place pad, and HFC / MPHSS equipment in leased / landlord approved space per details provided on site engineering drawings.*
  - ✓ *Trench (if required), place, connect and leak test all required pipe / hydrogen fuel lines.*
  - ✓ *Run, terminate, label and secure all required ground, electrical, supervisory, and alarm cabling.*
  - ✓ *Once installation of material is complete, coordinate fuel delivery, NOCC notification / maintenance ticket scheduling, and perform test / acceptance / and commissioning tasks per vendor instructions and Sprint provided MOP.*
  - ✓ *Once device is commissioned, complete system handoff to Operations' personnel*
  - ✓ *Prepare As-Built drawing updates to document equipment installation.*
  - ✓ *Load all necessary information into Sprint systems.*
  - ✓ *Provide ongoing data collection and reporting as contractually committed.*

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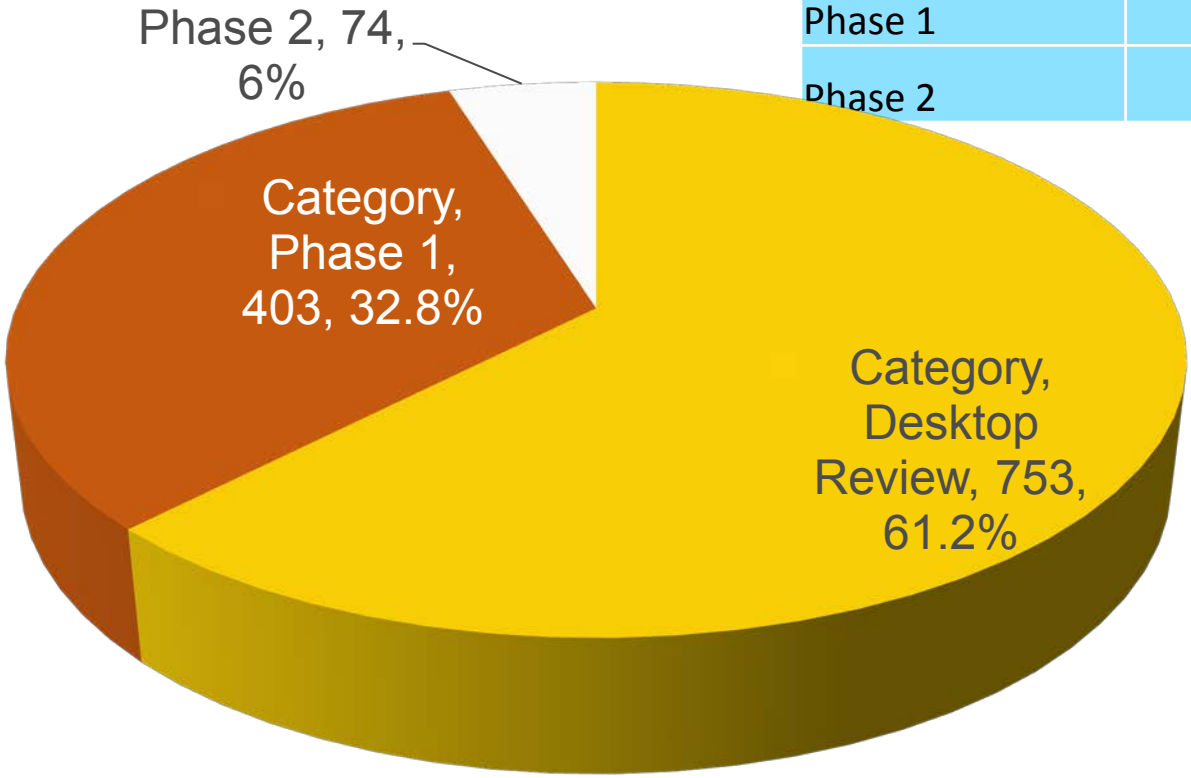
Technical Accomplishments and Progress

Site Fallout Breakdown:

Desktop Review	753
Phase 1	403
Phase 2	74



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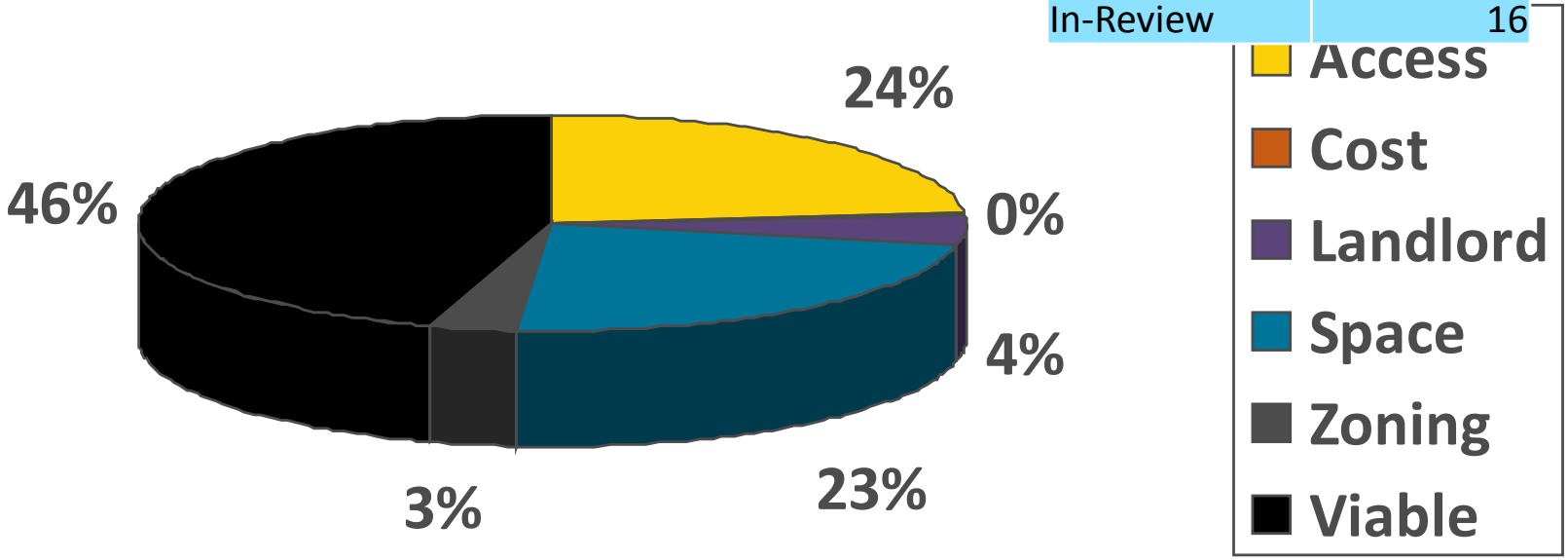
Technical Accomplishments and Progress

- Phase 1 to 2 fallout:

Access	162
Cost	3
Landlord	30
Space	172
Zoning	33
Viable Site	342
In-Review	16



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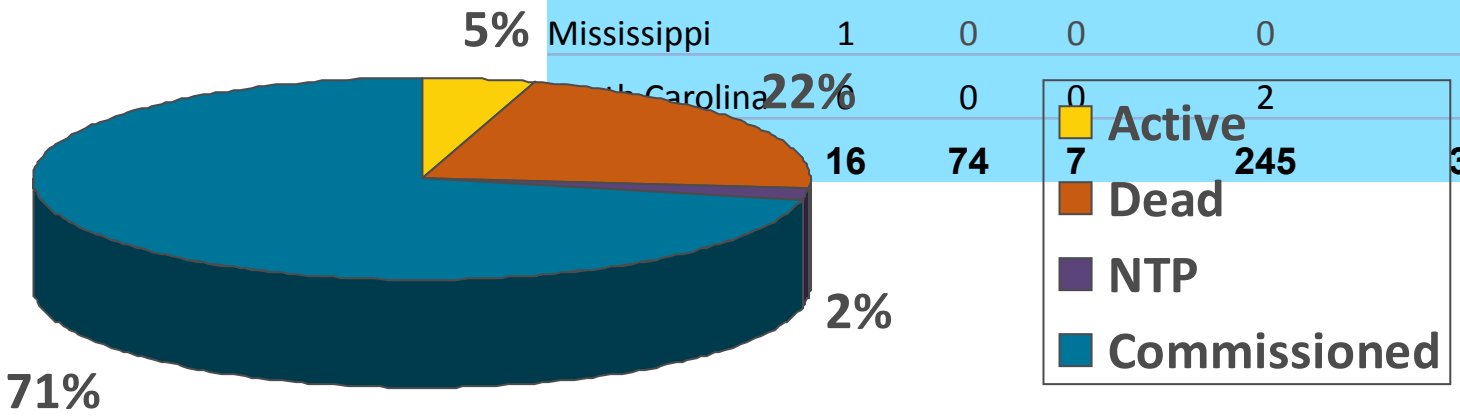
Technical Accomplishments and Progress

Phase 2 Status:

State	Active	Dead	NTP	Commissioned	Grand Total
California	0	23	1	75	99
Connecticut	1	8	0	28	37
New Jersey	1	26	0	38	65
New York	0	14	1	54	69
Louisiana	4	1	0	8	13
Texas	9	2	5	40	56
Mississippi	1	0	0	0	1
[illegible] Carolina	0	0	0	2	2
	16	**74**	**7**	**245**	**342**



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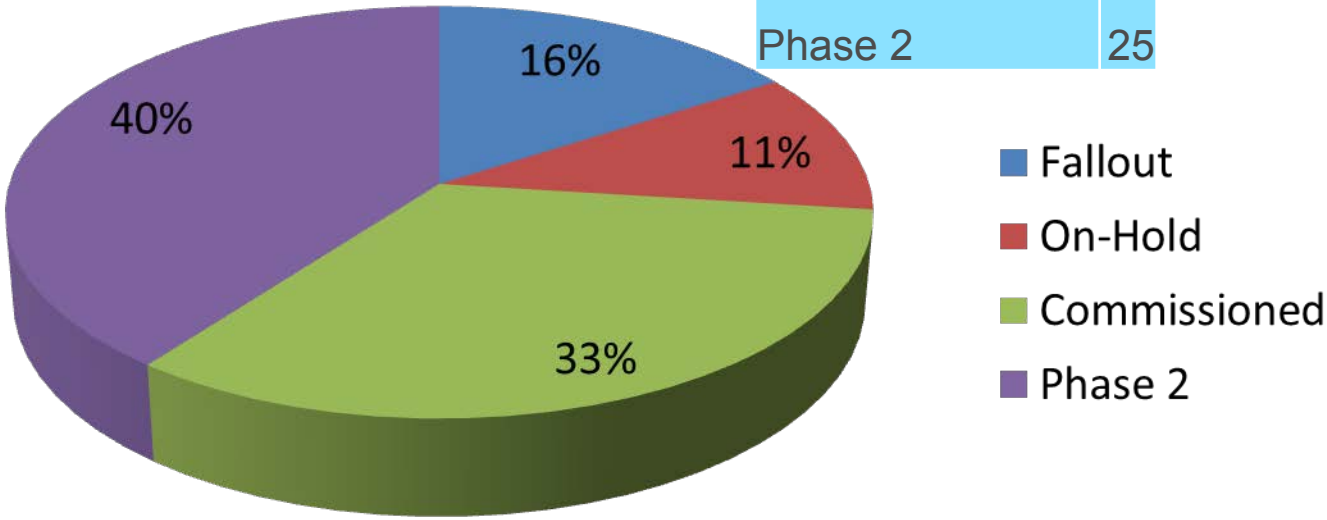
Technical Accomplishments and Progress

- Retrofit Status:

Fallout	10
On-Hold	7
Commissioned	21
Phase 2	25



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Collaborations

- ***Project Partners***
- *A&E Firms*
- *Black & Veatch*
- *Burns & McDonnell*

- *PEM Fuel Cells*
- *Altergy*
- *ReliOn*

- *Hydrogen Fuel Storage & Supply*
- *Air Products and Chemicals, Inc.*
- *Champion Energy*

- *Deployment Management*
- *Ericsson Services, Inc.*

- *End User*
- *Sprint - Nextel*

New Installation Summary

State	Original	Revised
California	100	76
Connecticut	30	29
Louisiana		9
Mississippi		2
New Jersey	65	38
New York	65	55
North Carolina		2
Texas		49
Total	260	260

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ARRA Project Summary

Relevance

- *Implementation plan establishes HFC presence, on the Sprint Network, in three new states thus introducing the technology to numerous AHJs.*
- *To support these deployments, building officials are being educated in the technology to ensure code compliant installations; construction, trade and service personnel are being trained / certified on the equipment to install, commission and service these devices.*
- *Jobs are being created, as well as retained, to support this program in the form of direct employment at all project partners, as well as indirect employment at all levels of the supply chain.*

Approach

- *Phased approach facilitates project success (demonstrated positive track record in previous major product rollouts) while minimizing financial impact to the project (GO/No GO decision points help preserve limited capital funds).*

Technical Accomplishments and Progress

- *Our deployment processes are working and obstacles are being overcome as we move the project forward. Of critical importance is ensuring the product pipeline is filled and capable of providing equipment when necessary.*

Collaborations

- *Working with our project partners to investigate potential design changes to permit less costly rooftop installations, as well as integrated on-site hydrogen generation.*

Future Work

- *"Design solutions to cost effectively address rooftop installation requirements.*
- *Continue to seek changes to NFPA code regarding Hydrogen Setback Distances.*
- *Modify grant contract to reflect reduced retrofit quantities, as well as the In-Direct Rate issue.*
- *Continue to investigate modular, scalable reformer based fuel cell technology to satisfy backup power requirements at sites which have fallen out of consideration.*

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Part II: Backup Power in Rooftop Installations
Background Summary

- *June 2012, a White Paper entitled "Hydrogen Fuel Cells – Providing Backup Power to Support Rooftop Installations" was delivered to the DOE Fuel Cell Office.*
- *The challenge is that rooftop applications have the potential to account for up to 30% of our target portfolio. At Sprint alone, this represents a possible market of 20,000 rooftops and Industry-wide we believe the target market exceeds 75,000 rooftops.*
- *Problem Statement - something must be done to allow for the more cost effective deployment of Fuel Cells to provide backup power for these types of sites.*
- *Cost delta - there is an approximate $65k premium cost to deploy HFC systems on rooftops*
- *To date, with an installed base of ~ 500 PEMs, Sprint has not placed any HFCs on rooftops.*

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Rooftop Fuel Cell Application Overview

- Rooftop installations:
  - Critical installations
    - Dense customer base
  - Current Technology Limitations
    - Batteries: weight, footprint, runtime issues
    - Generators: fuel storage and vibration issues
  - Market Opportunity
    - 75,000+ locations

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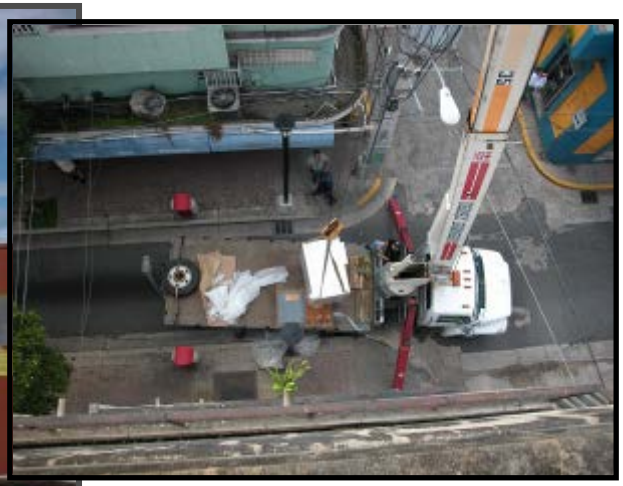
Rooftop Fuel Cell Current Challenges

- Restricted site access
  - Solutions required to avoid expensive crane/helicopter charges
- Excessive fuel storage weight
  - Existing approved steel solutions at 6000+ lbs exceed roof loading
- Lack of refueling solutions
  - Ground to rooftop delivery systems not yet fully developed
- Limited fuel delivery infrastructure
  - Limited options for high pressure fuel delivery in urban environment



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Rooftop Fuel Cell Proposed Solutions

Challenge - Restricted Site Access

- Proposed DOE Supported Solution:
  - Modular Fuel Cell Development
    - Each component should be able to be carried by a single worker up a single width stair case or ladder (through a manhole) to the roof.
    - The modular design must accommodate the electrical and tubing connections with sufficient space allowed to make the connections after assembly on the rooftop.
    - The final assembly should be designed to fit on a standard rail system so that it can be placed in the lineup with the radio equipment.
    - Modular assembly must not compromise the respective certifications for the fuel cell.
    - Current Technology Readiness Level (TRL): 5-6
    - Proposed DOE supported TRL: 7

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Rooftop Fuel Cell Proposed Solutions

Challenge – Excessive Fuel Storage Weight

- Proposed DOE Supported Solution:
  - Lightweight Rooftop Hydrogen Storage Development
    - Lightweight composite storage tanks that can support 5000 psi with a hydrogen capacity of at least 72 hours of fuel cell operation
    - The rooftop storage units will be connected to a permanently installed Remote Ground Mount for Hydrogen Refueling System (a separate R&D request) to mitigate issues such as those liabilities associated with handling flex hoses in high wind during storm condition.
    - Current TRL: 5-6
    - Proposed DOE supported TRL: 7-8

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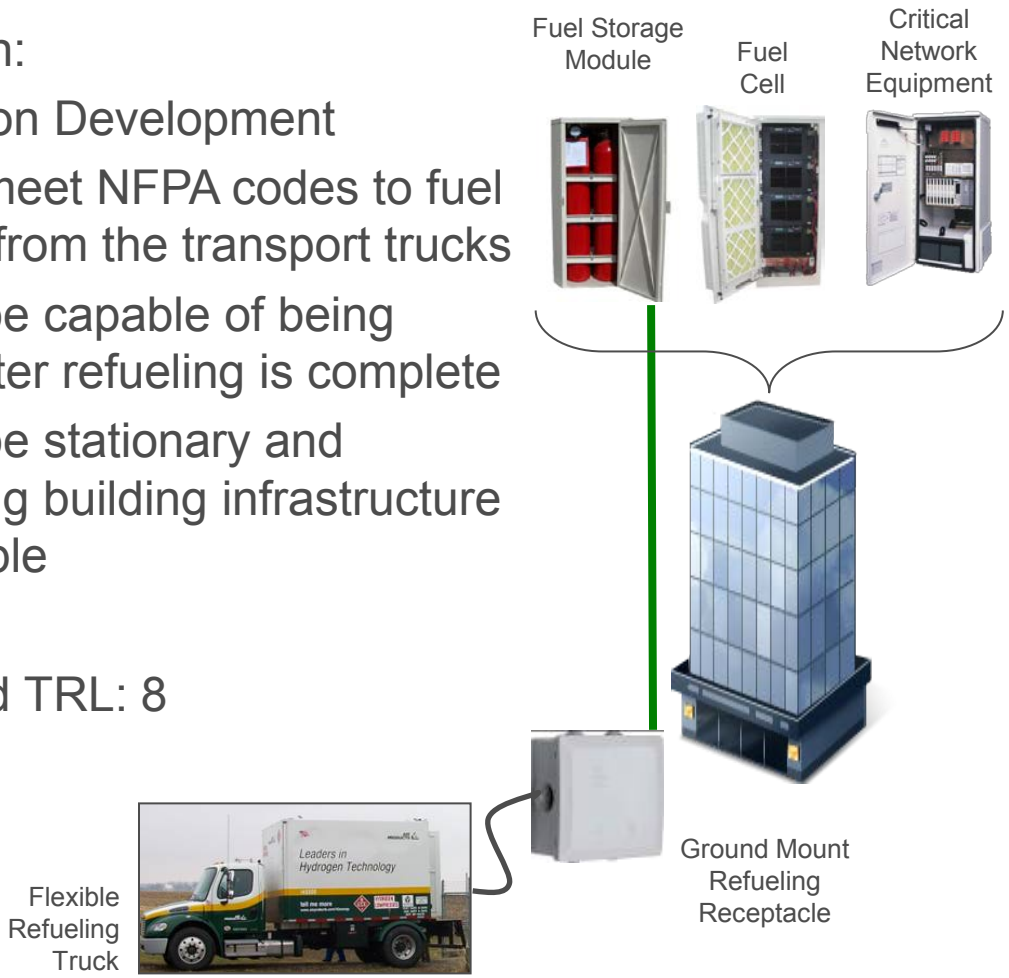
Rooftop Fuel Cell Proposed Solutions

Challenge – Lack of Refueling Solutions

- Proposed DOE Supported Solution:
  - Remote Ground Mount Solution Development
    - All piping systems must meet NFPA codes to fuel the rooftop storage units from the transport trucks
    - All piping systems must be capable of being purged of all hydrogen after refueling is complete
    - All piping systems must be stationary and integrated with the existing building infrastructure systems whenever possible
    - Current TRL: 6-7
    - Proposed DOE supported TRL: 8



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Rooftop Fuel Cell Proposed Solutions

Challenge – Limited Fuel Delivery Infrastructure

- Proposed DOE Supported Solution:
  - High Capacity Urban Delivery Vehicle Development
    - The delivery truck – composite tank design must have multiple sizes to accommodate maneuvering in tight urban environments.
    - Carbon fiber reinforced tanks of 5000 psi and 10,000 psi compressed hydrogen storage
    - Storage and delivery of hydrogen as a cryogenic liquid with minimal hydrogen boil-off or on-site compression may be necessary to drive delivery model economics
    - Current TRL: 5-6
    - Proposed DOE supported TRL: 7-8

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Definition Of Technology Readiness Levels

Source: http://esto.nasa.gov/files/trl_definitions.pdf

TRL 5 - System/subsystem/component validation in relevant environment:
Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces.

TRL 6 - System/subsystem model or prototyping demonstration in a relevant end-to-end environment (ground or space):
Prototyping implementations on full-scale realistic problems. Partially integrated with existing systems. Limited documentation available. Engineering feasibility fully demonstrated in actual system application.

TRL 7 - System prototyping demonstration in an operational environment (ground or space):
System prototyping demonstration in operational environment. System is at or near scale of the operational system, with most functions available for demonstration and test. Well integrated with collateral and ancillary systems. Limited documentation available.

TRL 8 - Actual system completed and "mission qualified" through test and demonstration in an operational environment (ground or space):
End of system development. Fully integrated with operational hardware and software systems. Most user documentation, training documentation, and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification and Validation (V&V) completed.

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