VSS138

2014 DOE Vehicle Technologies Office Review Presentation

EV Project - Solar-Assisted Charging Demo

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2014 U.S. DOE Hydrogen Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting

June 16-20, 2014

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Overview

Timeline
- Start date August 2009
- End date September 2014
- 80% complete

Barriers
- Integrating multiple technologies
- Securing site hosts
- Market acceptance of EVs
- Securing cost-share partners

Budget
- Total project funding
  - DOE share $6.8 million
  - Matching partners' share $6.8 million
  - Yearly spending:
    FY10 $514,000
    FY11 $1,661,000
    FY12 $2,777,000
    FY13 $1,283,000
    FY14 $280,000 (through March)

Partners
- Project lead – ORNL
- Project partners – TVA, Nissan, EPRI, State of Tennessee, and eight site hosts across Tennessee

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Objectives

- Advance the adoption of clean vehicle technology (plug-in vehicles) through:
  - The deployment of 125 solar-assisted EV charging stations and 19 non-solar-assisted EV charging stations
  - Encouraging the acquisition and use of plug-in vehicles
  - Creating key partnerships across Tennessee
- Integrate renewable energy, vehicle charging, grid connection, and external battery storage into a single design
- Develop and test peak-shaving algorithms for offsetting plug-in vehicle grid demand
- Collect and analyze vehicle charging data for understanding grid impacts and station use patterns

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Approach – Design Components

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Approach – Nissan Installation

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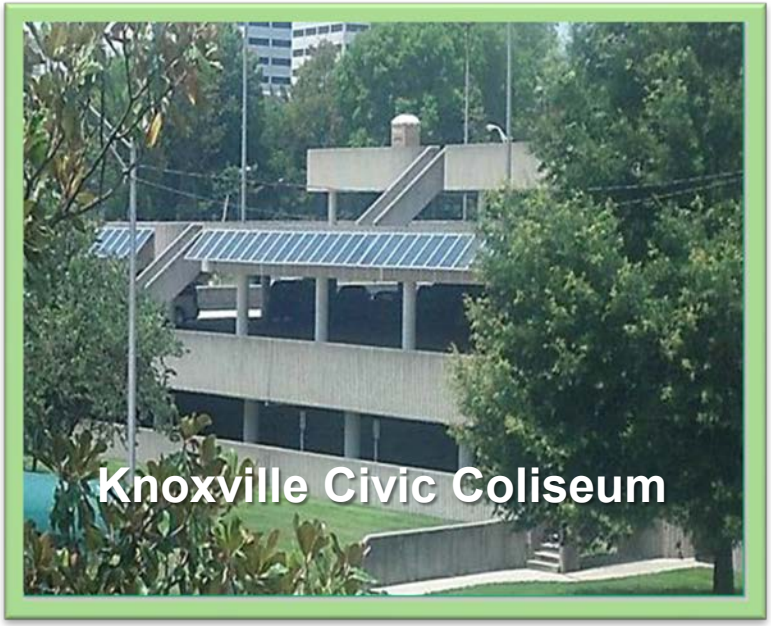
Approach – ORNL Non-Solar and Knoxville Solar Installations



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Approach – Other Installations

ORNL Solar Assisted

Vanderbilt University

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Technical Approach

- Design stations with independent grid-connected elements of solar power, EVSEs, and external batteries
- Design solar power installation to offset grid demand at all times when solar power is being produced
- Include grid connection so drivers can charge vehicles without dependence on solar production (night and cloud-covered days)
- Connect external battery to the grid to offset grid demand at selected times
- Install sufficient solar capacity to support 10,000 miles of EV driving per year, per vehicle parking space, on renewable power

Technical Approach - Continued

- Use commercially-available, UL-listed components given public use of the stations
- Develop real-time website to display cars charging, solar production, state of external battery, and ‘net solar vs. demand’ for project to date
- Collect and analyze data on charging station utilization and energy use (consistent with requirements of the DOE grant)
- Develop an ongoing statewide team for review of data and for making strategic choices (TEVAC – Tennessee Electric Vehicle Advisory Council)

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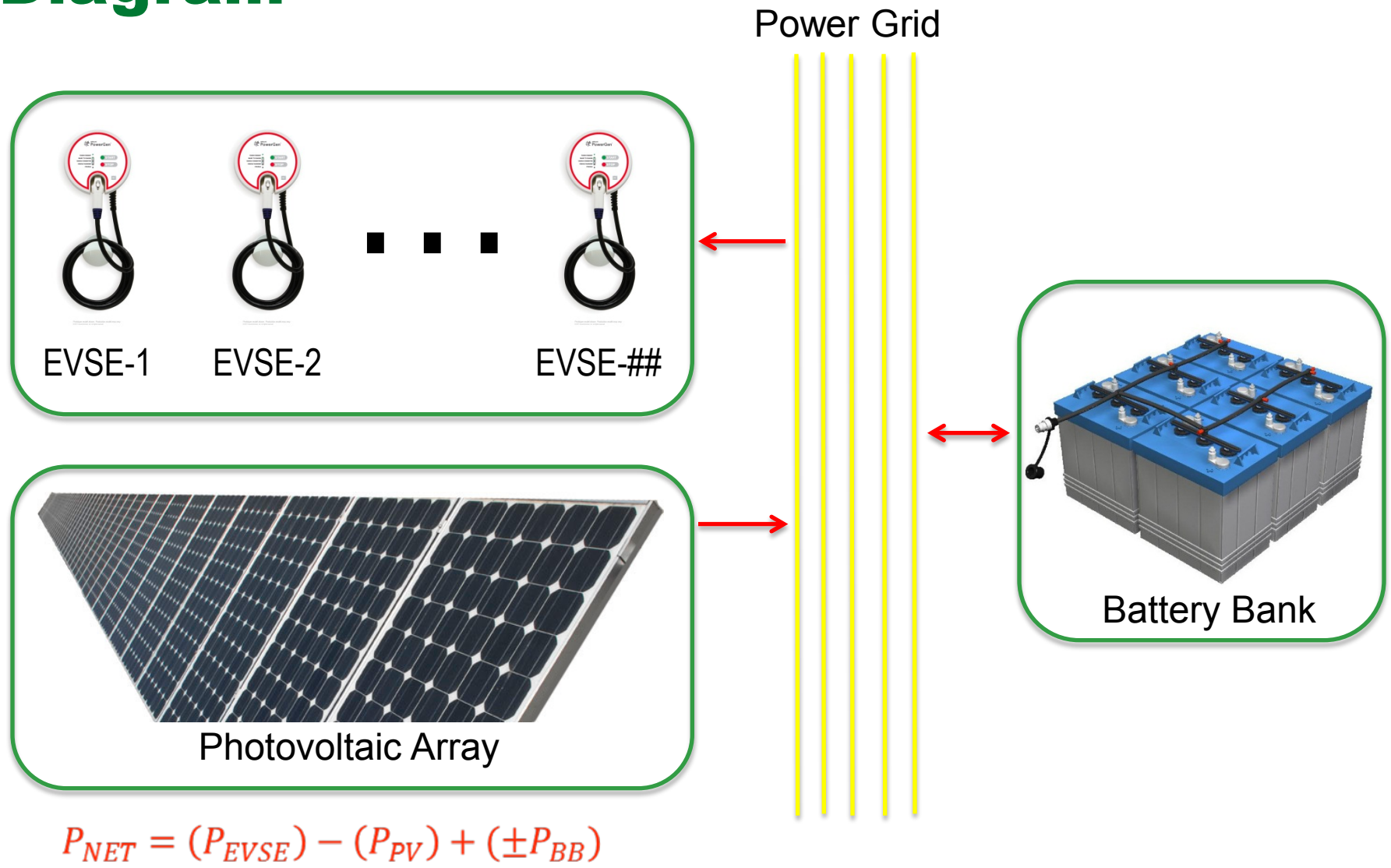
Technical Approach - General System Diagram



$$P_{NET} = (P_{EVSE}) - (P_{PV}) + (\pm P_{BB})$$

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Technical Accomplishments and Progress

- Installed 144 fully-functional EV charging stations
- Cost-share partners made the agreed-to investments and installed the agreed-to infrastructure
- Successfully integrated the power grid, solar power, EVSE, and external batteries into a single design
- Developed a real-time website for monitoring the solar-assisted station at ORNL https://extwebapps.ornl.gov/pvev_ext
- Tested, selected, and deployed a peak-shaving algorithm to optimize use of the external battery
- Converted raw data into user-friendly energy consumption and station utilization charts
- Embarked on the creation of an I-40 corridor EV charging route across Tennessee

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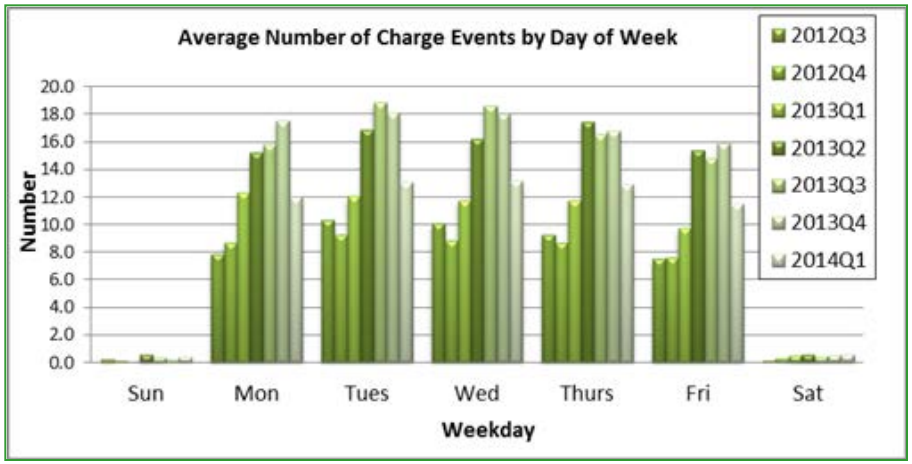
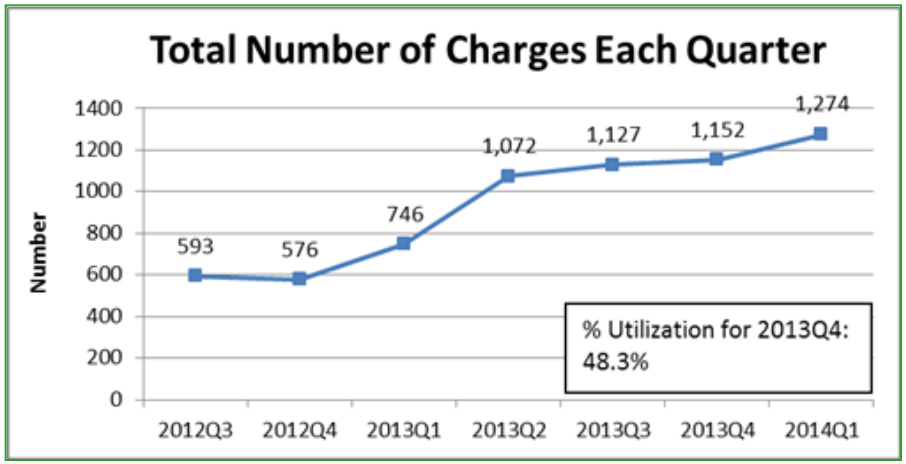
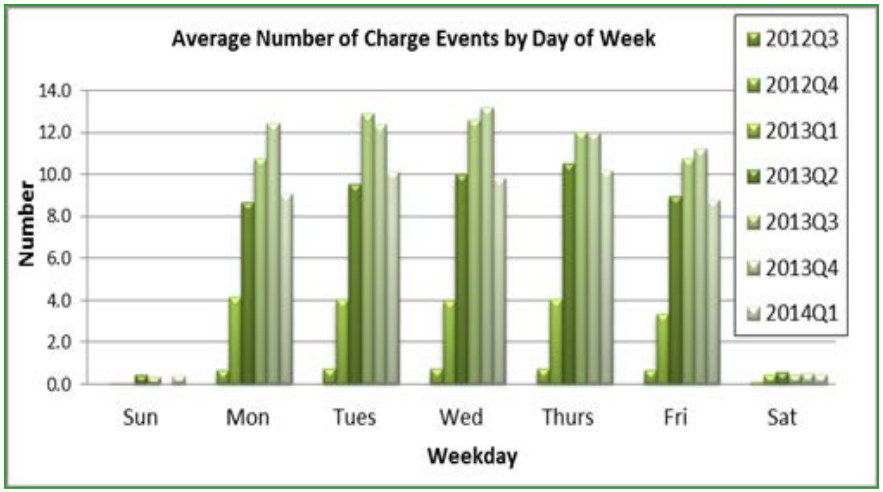
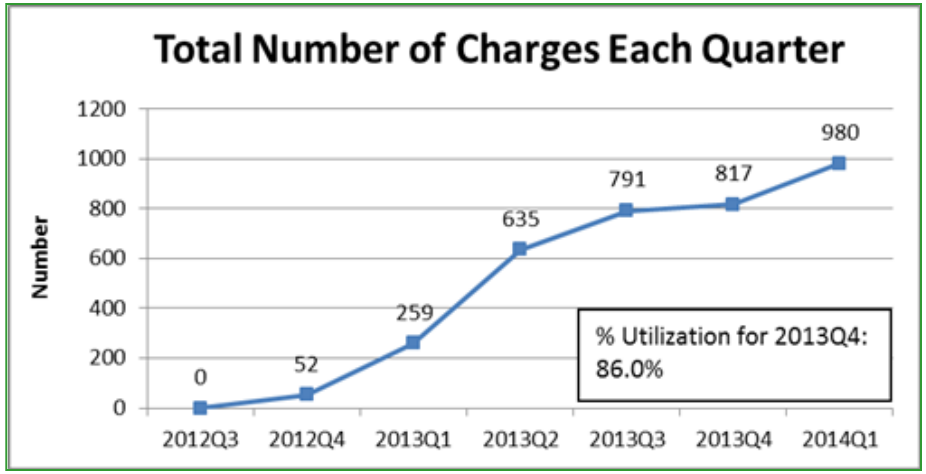
Station Utilization – ORNL Overall





Station Utilization – ORNL Non-Solar-Assisted





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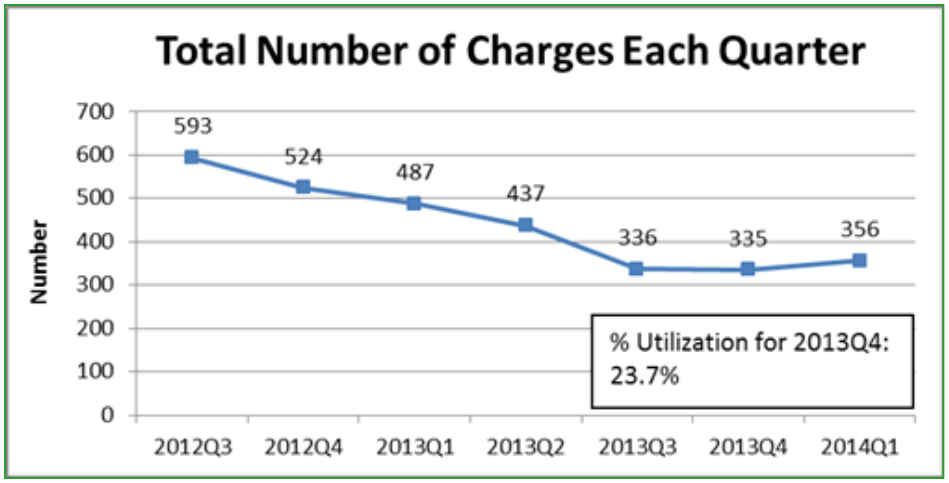
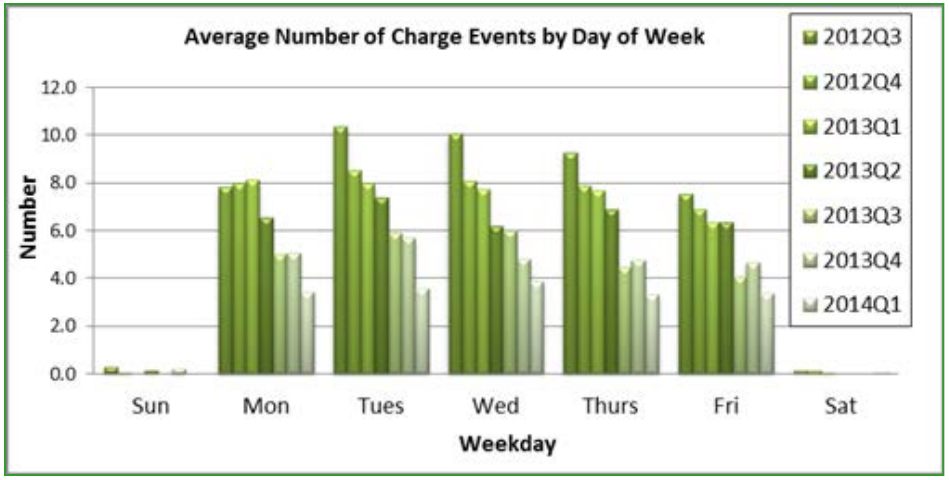
Station Utilization – ORNL Solar-Assisted





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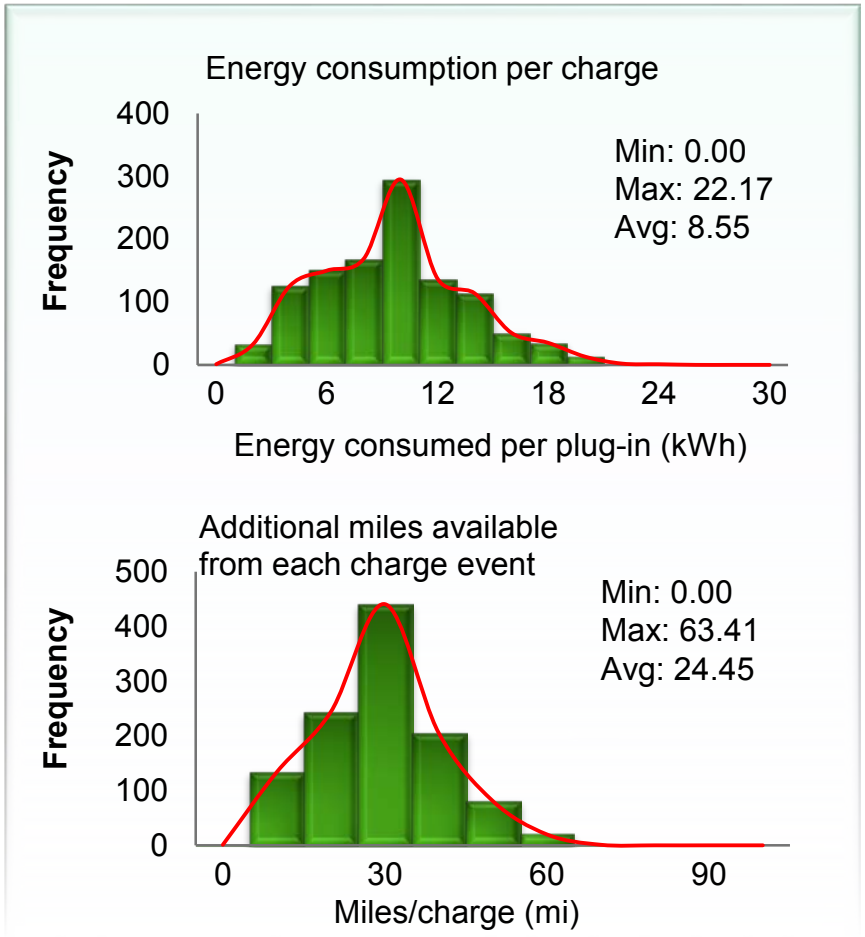
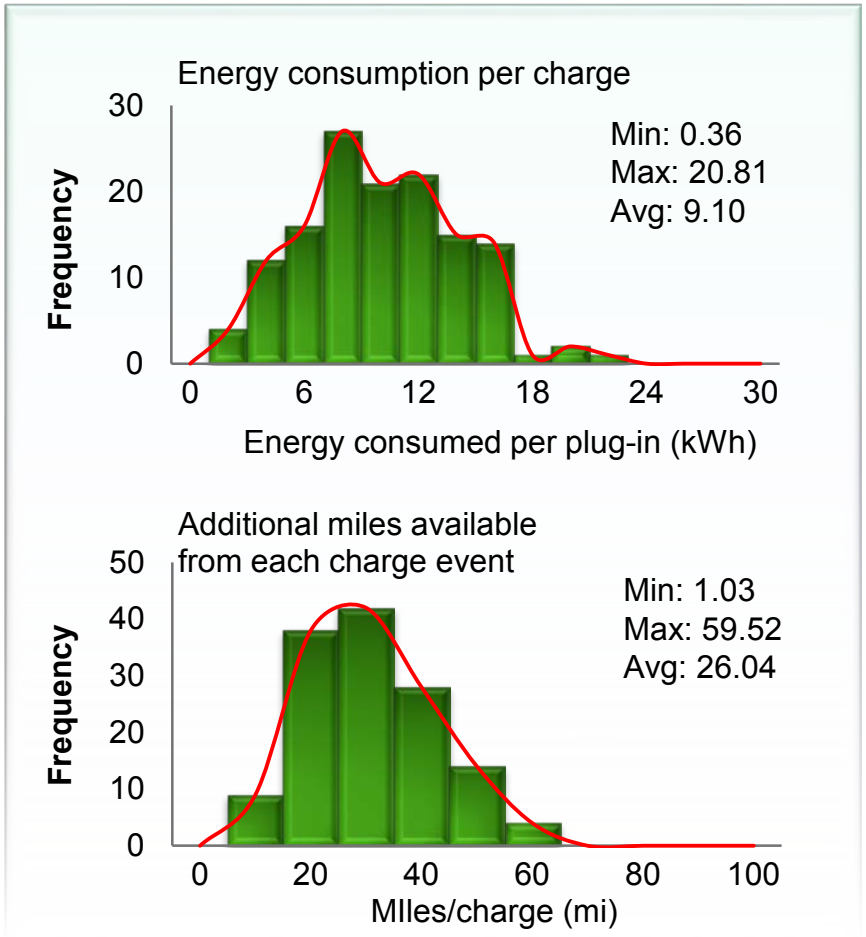
Comparison of ORNL Campus and Public Setting – Energy Consumption

ORNL (Quarter 3, 2013)



Nashville State (Quarter 3, 2013)



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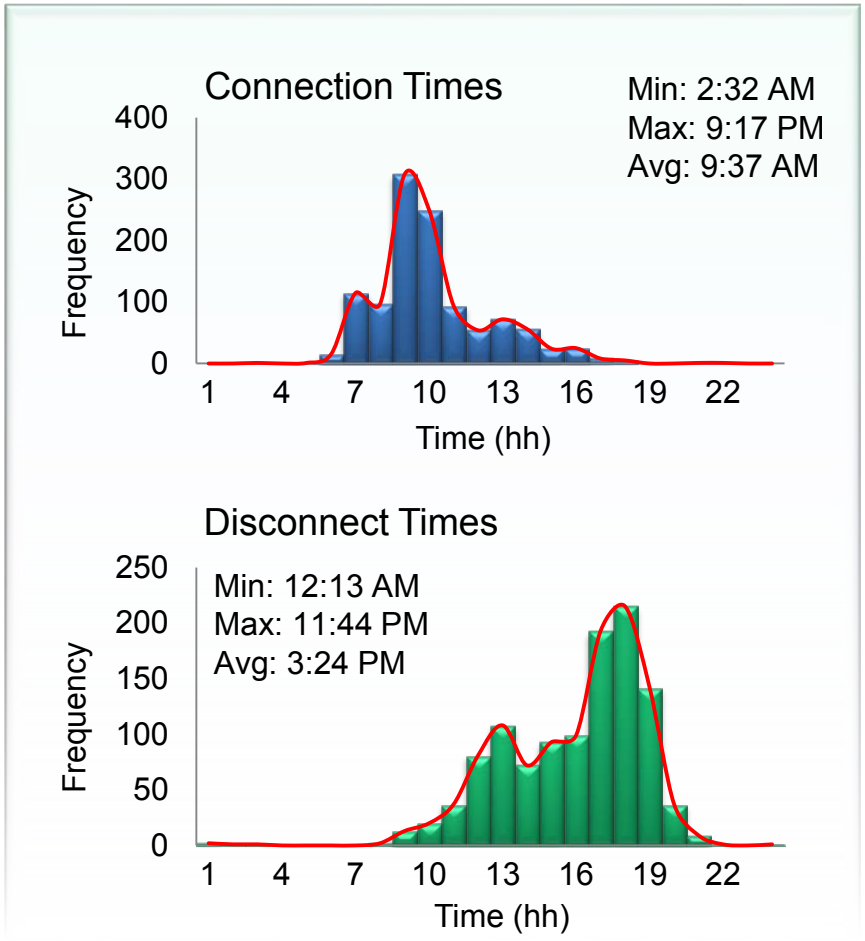
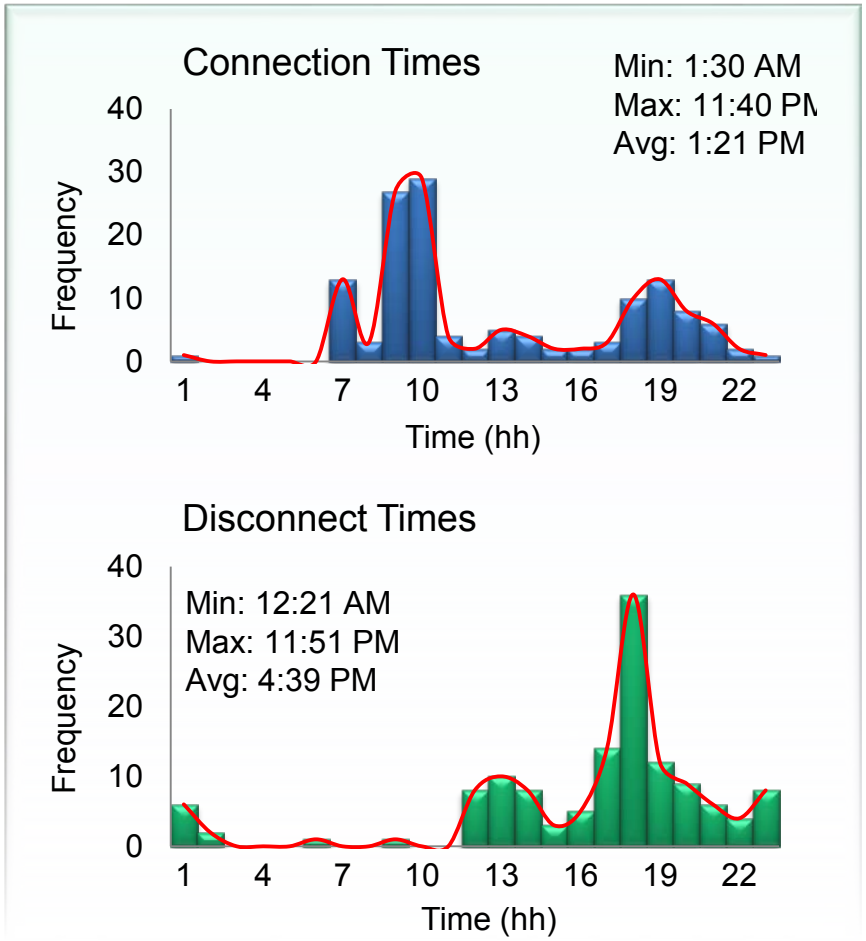
Comparison of ORNL Campus and Public Settings: Charging Times

ORNL (Quarter 3, 2013)



Nashville State (Quarter 3, 2013)



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Technical Accomplishments and Progress - Peak Shaving Algorithms

Increasing Complexity

Control System #1

- Open-loop system
- Discharge/charge batteries at constant rate
- Defined times to start and stop discharging
- Does not take PV power and EV charging load into consideration
- Charging occurs during the night time

Control System #2

- Closed-loop system
- Takes into consideration PV power and EV charging load
- Rate of discharge determined by number of charging EVs (linear function)
- Charging occurs during the night time

Control System #3

- Similar to control system #2
- Uses a sigmoid function to determine the rate of discharge
- Charging occurs at night and times during the day where PV generation is greater than EV charging load

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Technical Accomplishments and Progress - Peak Shaving Algorithms

- The most shaving occurred for control systems #2 and #3.
- Control #2 has slightly better results for a workplace setting.
- Control #3 has the best results for a public setting.

Actual Load Shaved/Potential Load Shaved

Control System	ORNL	Knoxville
1	33.99%	0.37%
2	60.61%	74.74%
3	59.03%	76.62%

Battery Use Efficiency

Control System	ORNL	Knoxville
1	17.97%	0.17%
2	100%	100%
3	100%	100%

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Collaborations/Partnerships

- **Nissan North America** – Installed 30 solar-assisted charging stations at a cost of more than $1.7 million
- **Tennessee Valley Authority with EPRI** – Installed 36 solar-assisted charging stations at a cost of more than $2.75 million
- **State of Tennessee** – Provided vehicle incentives in excess of $1.8 million and infrastructure commitment of $2.5 million
- **Eight site hosts** including the State of Tennessee, Nashville Metro Government, University of Tennessee, Vanderbilt University, City of Knoxville, City of Chattanooga, Shelby County in Memphis, and Tennessee Valley Authority (TVA)

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Future Work

- **Potential partnership (CRADA) with Car Charging to continue analyzing data in Tennessee to:**
  - Improve utilization of all Blink stations across Tennessee
  - Enhance DOE's 'return on investment' by growing the use of the stations
  - Enable improved planning for future infrastructure
  - Continue grid impact/peak shaving analysis to better understand ways to mitigate EV charging impacts to the grid
- **Complete the State of Tennessee funded project for additional infrastructure**
  - Interstate 40 corridor for fast charging stations
  - Additional Level 2 charging
  - Selected metro sites for fast chargers
- **Implement post-project plan for employee use of stations at ORNL**
- **Continue with the Tennessee Electric Vehicle Advisory Council**

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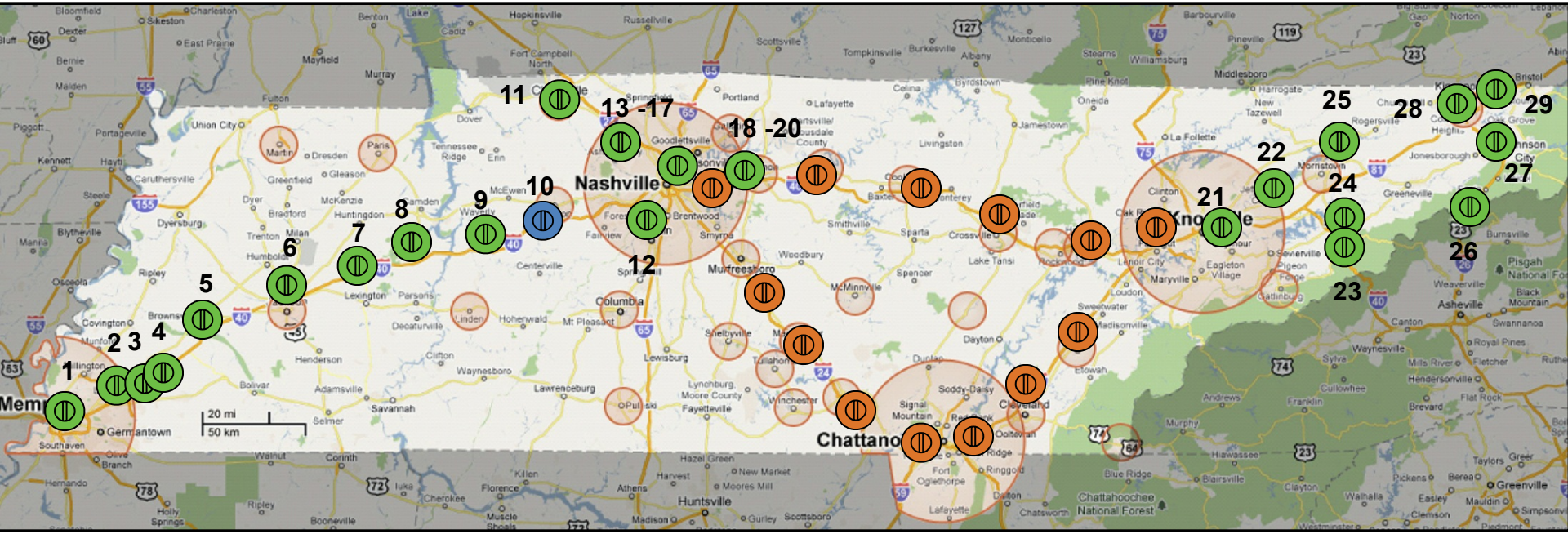
DC Fast Chargers in Tennessee: Expanding the infrastructure



Original map overlays by Ecotality

Existing

Potential future sites

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Summary Slide

- **Objectives Have Been Met**
  - Planned charging stations are installed and functioning
  - Cost share dollars have been spent or are being spent
  - Peak shaving algorithm has been developed and deployed
  - Key partnerships are in place across Tennessee
  - Data is being collected, summarized, and used
  - The final report is in preparation and will be submitted by 9/30/14
  - Stayed within budget and met all deliverables
- **Future actions offer excellent potential**
- **Project was not reviewed last year**

ETSD Energy & Transportation Science Division

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