IEEE Insulated Conductor Committee

Spring Meeting

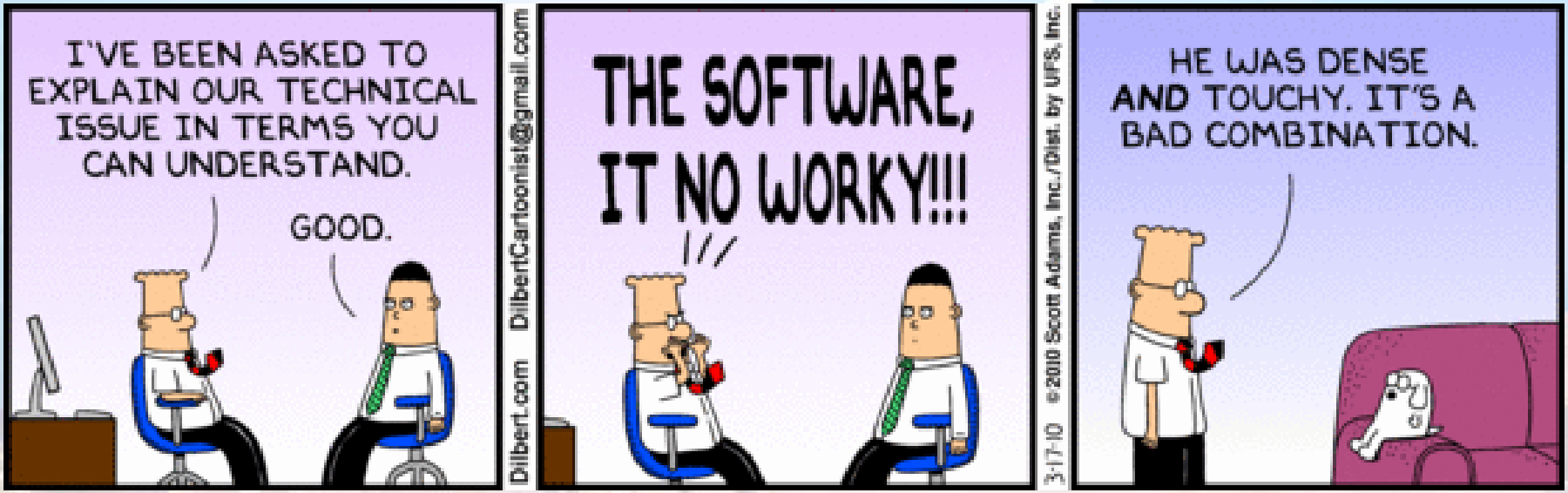
March 22, 2010

Paul H. Allen, P.E.

pallen@nespower.com

Reliable Public Power Provider

An Engineer's Challenge

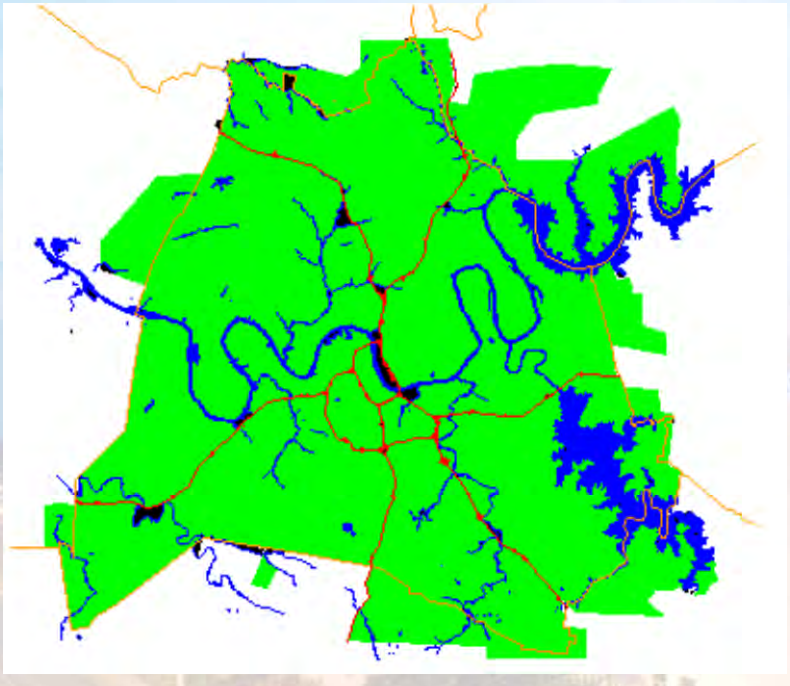


Reliable Public Power Provider

This week in Nashville

- ICC Meeting – Su, M, Tu, W
- Grand Ole Opry – Tu, F, Sa
- NHL Hockey – Tu, Th, Sa
- Opry at the Ryman – Th
- SEC Baseball – Tu, W, F
- Country Music Hall of Fame – M-F
- The Hermitage – M-F
- The Frist Center – M-F

About NES



- 700 square miles of service territory
- approx. 360,000 Customers
- 55.8% of revenue from Commercial & Industrial customers
- Over 5,700 pole line miles
- Over 104,000 street lights and private lights

About NES

- 11th largest public electric utility in the United States based on customers served
- 12th largest based on electric revenues
- 17th largest based on megawatt-hour sales
- In fiscal year 2009, NES delivered over 12,100 gWh of electricity to commercial and residential customers, in addition to serving the public lighting needs in the area

About NES

- 62 Major substations
- 161 kV and 69 kV transmission voltages
- 23.9kV, 13.8kV and 4kV distribution voltages
- Secondary network system in downtown

- Summer peak 2,712 MW July 2008
- Winter peak 2,447 MW January 2009

Reliable Public Power Provider

Plug-In Vehicle Impact on the NES Distribution System

Contact: Carla Nelson
cnelson@nespower.com

Reliable Public Power Provider

Plug-In Vehicles

- On July 22, 2008, Nissan announced the formation of a partnership with the State of Tennessee to promote zero-emission vehicles in Middle Tennessee.
  - Governor Bredesen agreed the state would explore strategies to help support the deployment of infrastructure for electric vehicles including charging stations
  - The state and other partners' initial focus would be on the region's heavily trafficked Interstate 24 and Interstate 65

Plug-In Vehicles

- On April 22, 2009, Nissan announced a project expansion in partnership with TVA and ORNL to develop and pilot solar-assisted charging stations
  - Governor Bredesen announced the state could invest funds toward developing the charging stations
  - Cities selected to pilot the charging stations include Nashville, Chattanooga, and Knoxville
  - At least one station is planned for each of the three cities

NES & Plug-In Vehicles

- Initial member of the Governor's Zero Emission Vehicle Partnership with Renault-Nissan
- NES and TVA are working with EPRI on studying the impact of plug-in electric vehicles on the electric distribution system
- Participate in site determination of public charging infrastructure, EVSE data analysis, and R&D work which could include various battery technologies and piloting new rates

NES & Plug-In Vehicles

- NES and Vanderbilt University collaboration on forecasting EV penetration at the neighborhood level including customer behavior modification incentives
- Member of the eTec DOE-FOA-28 Partnership to deploy EVs and charge infrastructure

Reliable Public Power Provider

eTec Partnership Stimulus Grant Funding

- $100 Million grant towards a $200 Million project
- Includes five geographically dispersed states – Tennessee, California, Arizona, Oregon and Washington State
- These states have partnered with Renault-Nissan to bring 4,700 electric vehicles, 10,950 Level 2 chargers and 260 Level 3 fast-chargers to market in 2010/2011

eTec Partnership Stimulus Grant Funding

- Nissan's Tennessee launch market cities are Nashville, Knoxville and Chattanooga
- Tennessee projected deployment: Up to 1000 Nissan EVs, 1000 Home EVSEs, 1200 Commercial EVSEs, 300 Public EVSEs, and 50 Level 3 DC Fast-Chargers
- www.theEVproject.com

Electric Vehicle Charging

- Current SAE Standards define 3 charging Levels:
  - Level 1: 110V – requires longest time to recharge, up to 18 hours
  - Level 2: 220V – believed to be the most likely for home applications, recharge time 4-8 hours
  - Level 3: commercial applications, fast charge, 20-50 minutes

SAE Standards

- J1772: Conductive Charge Coupler
- J2836/1 & J2847/1: Utility Programs
  - Initial ballot December 2009
- J2836/2 & J2847/2: EVSE Charging
  - Initial ballot 1Q 2010
- J2836/3 & J2847/3: Reverse Power Flow
  - Initial ballot mid 2010
- J2836/4 & J2847/4: Diagnostics
  - Initial ballot 4Q 2010
- J2836/5 & J2847/5: Vehicle Manufacturer Specific
  - Initial ballot 4Q 2010

Modeling Considerations and Scenarios

Distribution Impacts

- **Thermal Loading**
  - Secondary cables and circuits
  - Transformers
  - Primary circuits and components
- **Losses**
- **Voltage**
- **Imbalance**
- **Harmonics**
- **Protection System Impacts**
- **Advanced Metering**
- **EE devices**

PHEV Characteristics

- Different vehicle type
- Different Charging profile levels/Power Levels
- Time Profiles for charging
- Charger Spectrum Profile
- Define PHEV penetration levels and localized concentration scenarios

Circuit Characteristics

- Radial, network, etc.
- Voltage level
- Circuit length, suburban vs. urban vs. rural
- Available capacity
- % load class served from feeder

PHEV Penetration

- Distribution of PHEVs
- Define PHEV penetration levels and localized concentration scenarios
  - Deterministic
  - Probabilistic

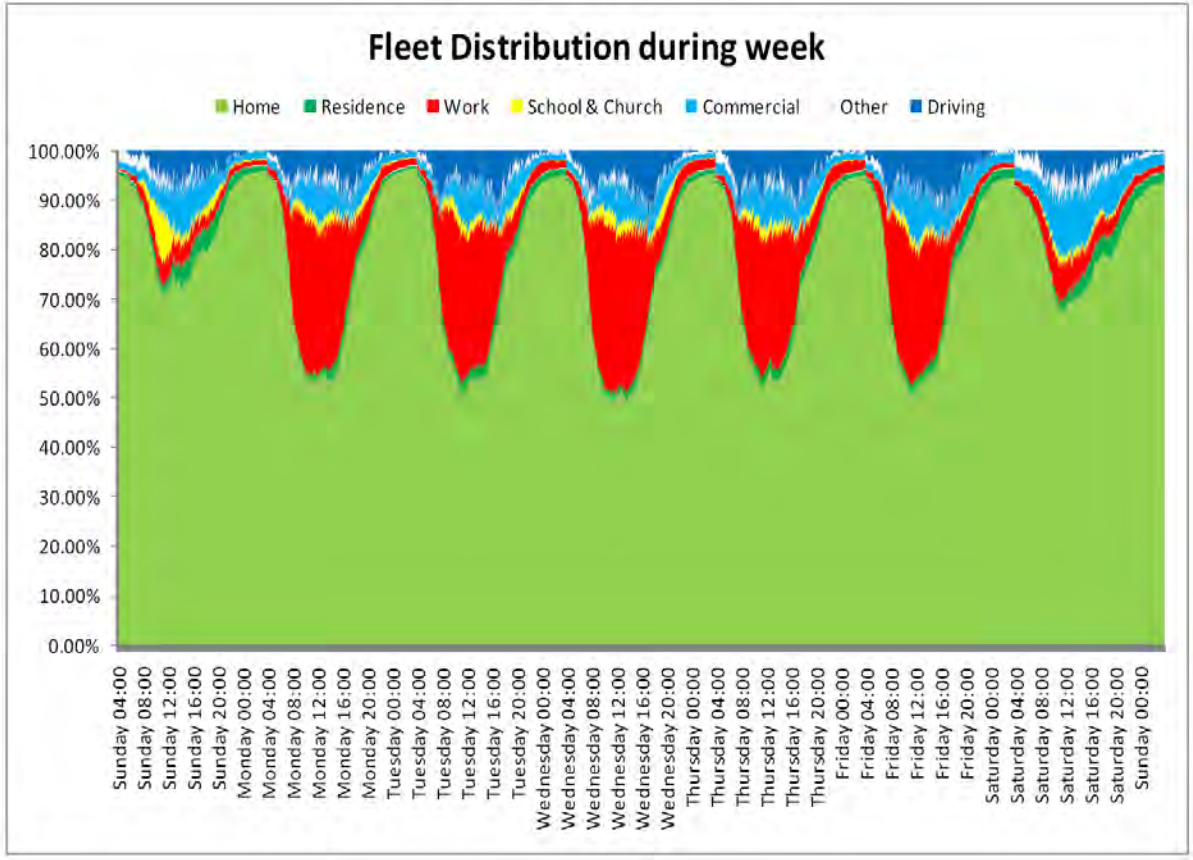
Circuit Loading

- Develop methodology for altering the load shapes
- Metered annual load profile characteristics
  - Primary distribution points
  - Customer classes served

NES Circuit Selection

National Household Travel Survey (2001)

- Charge at Home Scenario
  - Residential Circuit
  - 4kV distribution
  - Circuit ≈ 80% Loaded
  - Fits PHEV Buyer Profile
- Charge at Work Scenario
  - Commercial Circuit
  - Downtown Network



Source: Tate and Savagian (GM) SAE 2009-01-1311

Natural Resources Council of Maine's Survey of Toyota Prius and Honda Insight owners - Summer 2008

- Hybrid's best feature: **"social"** attributes (77%) – raising environmental consciousness and promoting fuel-efficient technologies
- Drive an average of 1400 miles per month
- 89% bought car new, 11% bought pre-owned
- 85% installed compact fluorescent light bulbs
- 69% lowered their thermostats in the winter
- 66% turned off/unplugged appliances more often
- 49% purchased Energy Star appliances
- 43% weatherized their home with new windows/doors, insulation, air sealing
- 24% switched heating fuels
- 14% carpooled
- 11% switched their electricity supply to renewables
- 9% had an energy audit

Customer Profile – Hybrid Buyers

- Higher income than avg. car buyer: >$100,000 per year
- Older than avg. car buyer: 2% 24 & younger, 29% between 45 & 54, 33% 55 and older
- More likely to be female
- Drive fewer miles on average
- Plan to keep car longer than avg. buyer: > 5 years
- Willing to pay more for green products

Customer Profile – Hybrid Buyers

- Higher levels of education
- Consume more organic food, yogurt, and decaffeinated coffee
- Above average tech savvy skills
- Online activities favor news & information websites and auctions (eBay)
- Twice as likely to ski, hike, or practice yoga
- 38% Democrat, 34% Independent, 14% Republican

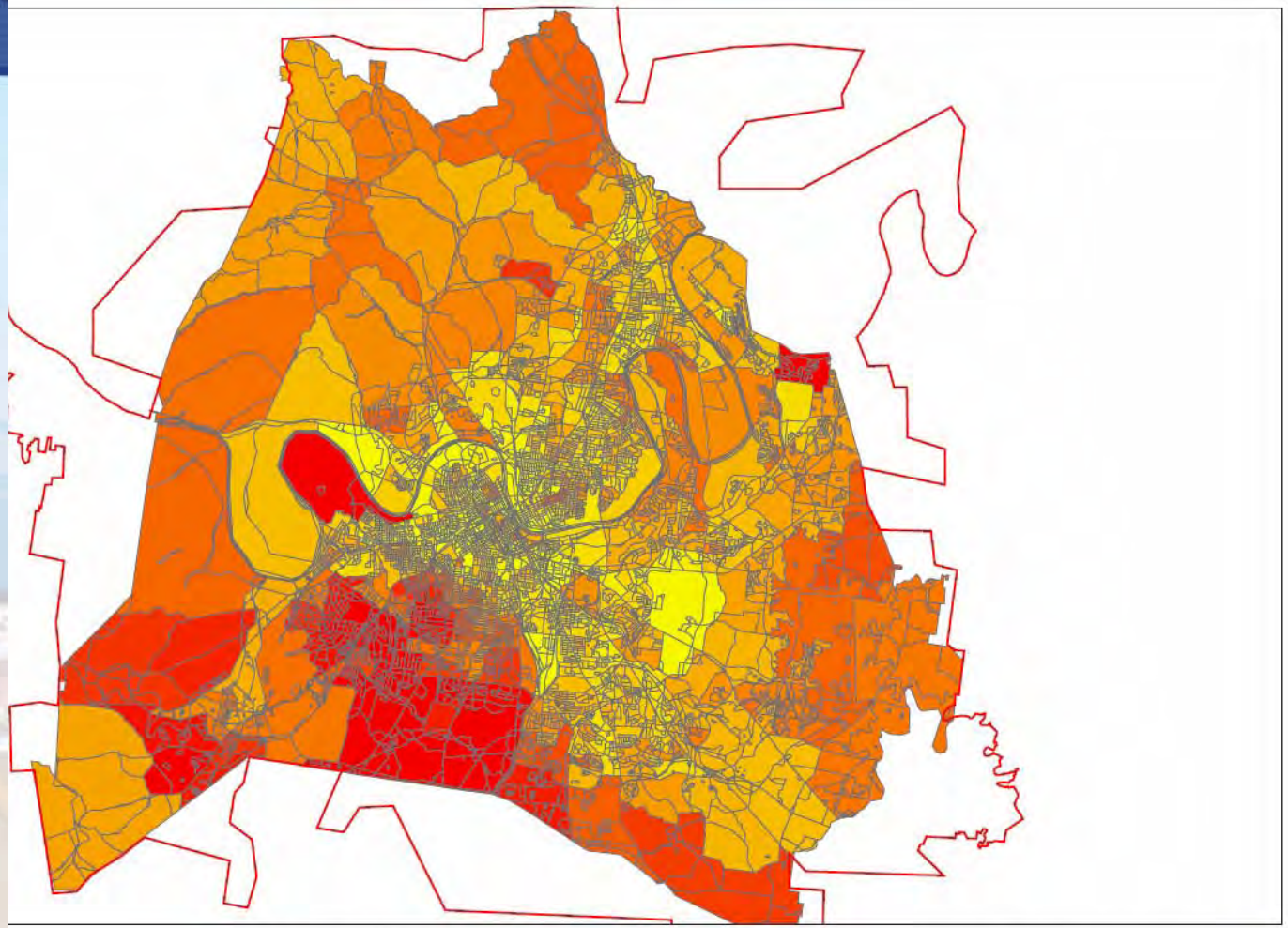
– Sources: J.D. Power 2004, J.D. Power 2007, Walter McManus, University of Michigan's Transportation Research Institute, 2007 Scarborough Research survey of 110,000 adults

Predicting Early EV Penetration Using Census Data

- Household Income
- Gender – Male, Female
- Education Level
- Population Density
- Travel Time to Work
- Age
- Political Affiliation

Reliable Public Power Provider

NES Service Area
Household Income

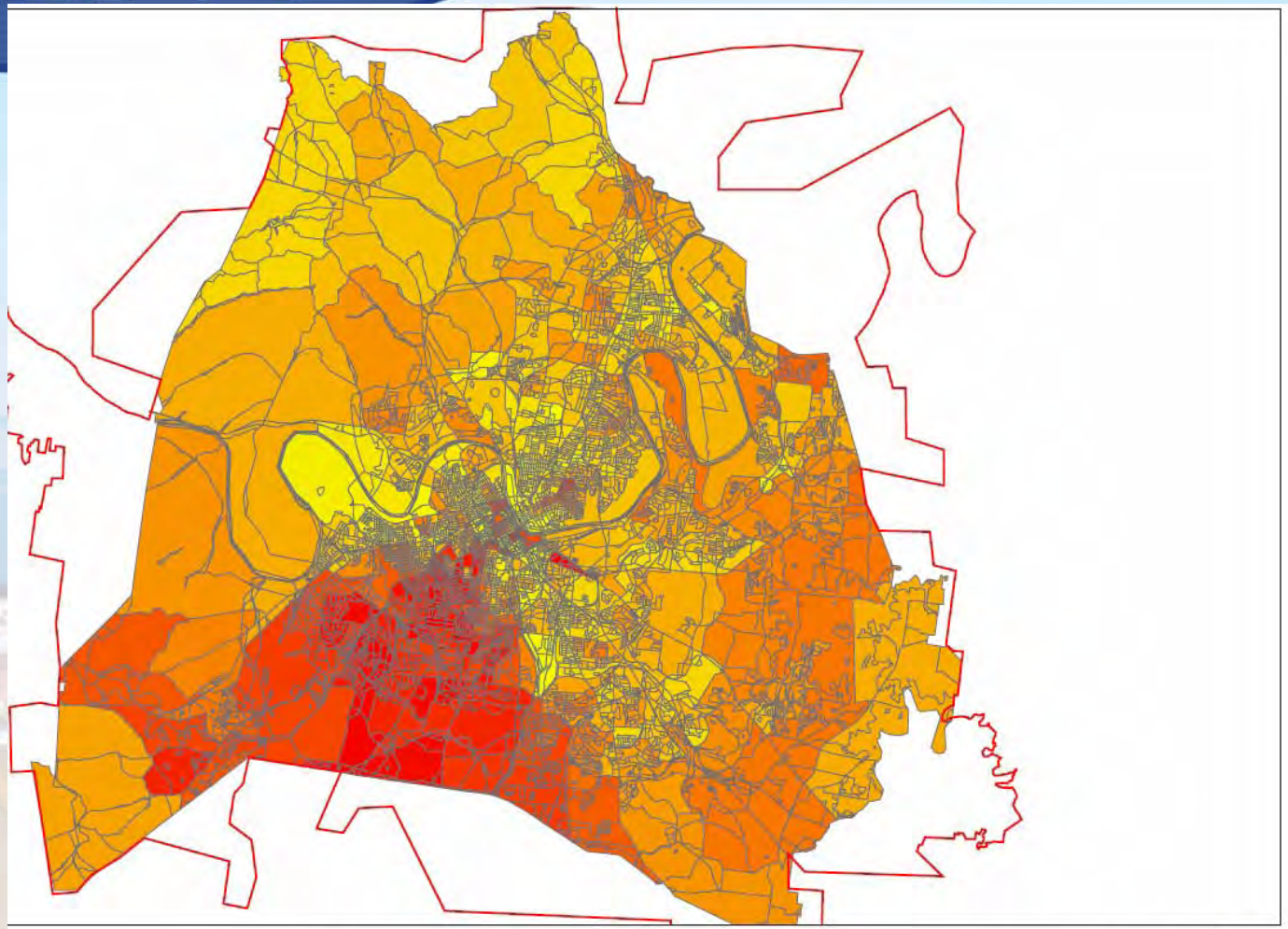


EPRI/TVA Distribution Impact Study 2009
Predicted Electric Car Penetration

Score Summary
Household Income

March 2009

NES Service Area
Education Level

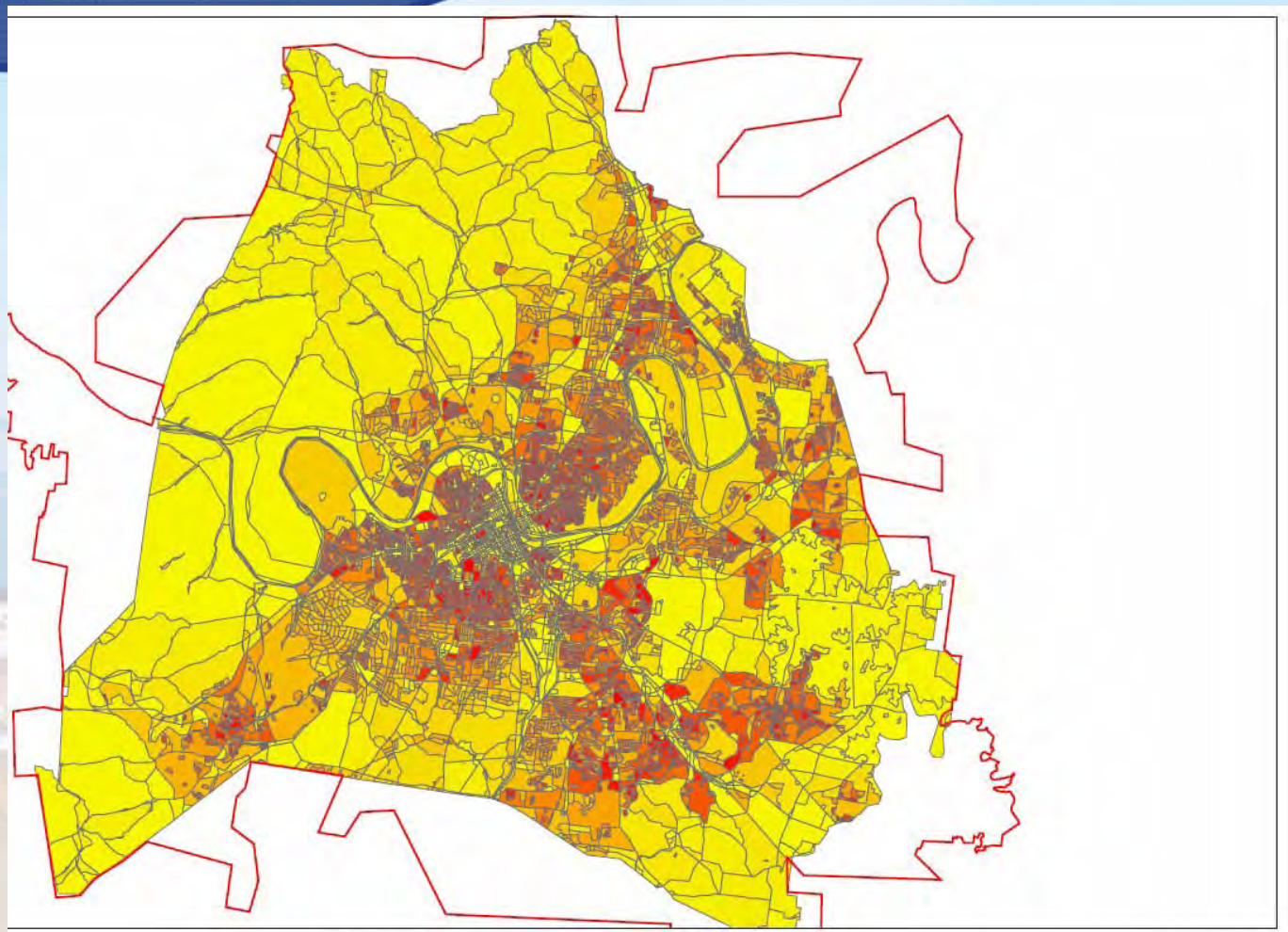


EPRI/TVA Distribution Impact Study 2009
Predicted Electric Car Penetration

Score Summary
Education Level

March 2009

NES Service Area Population Density



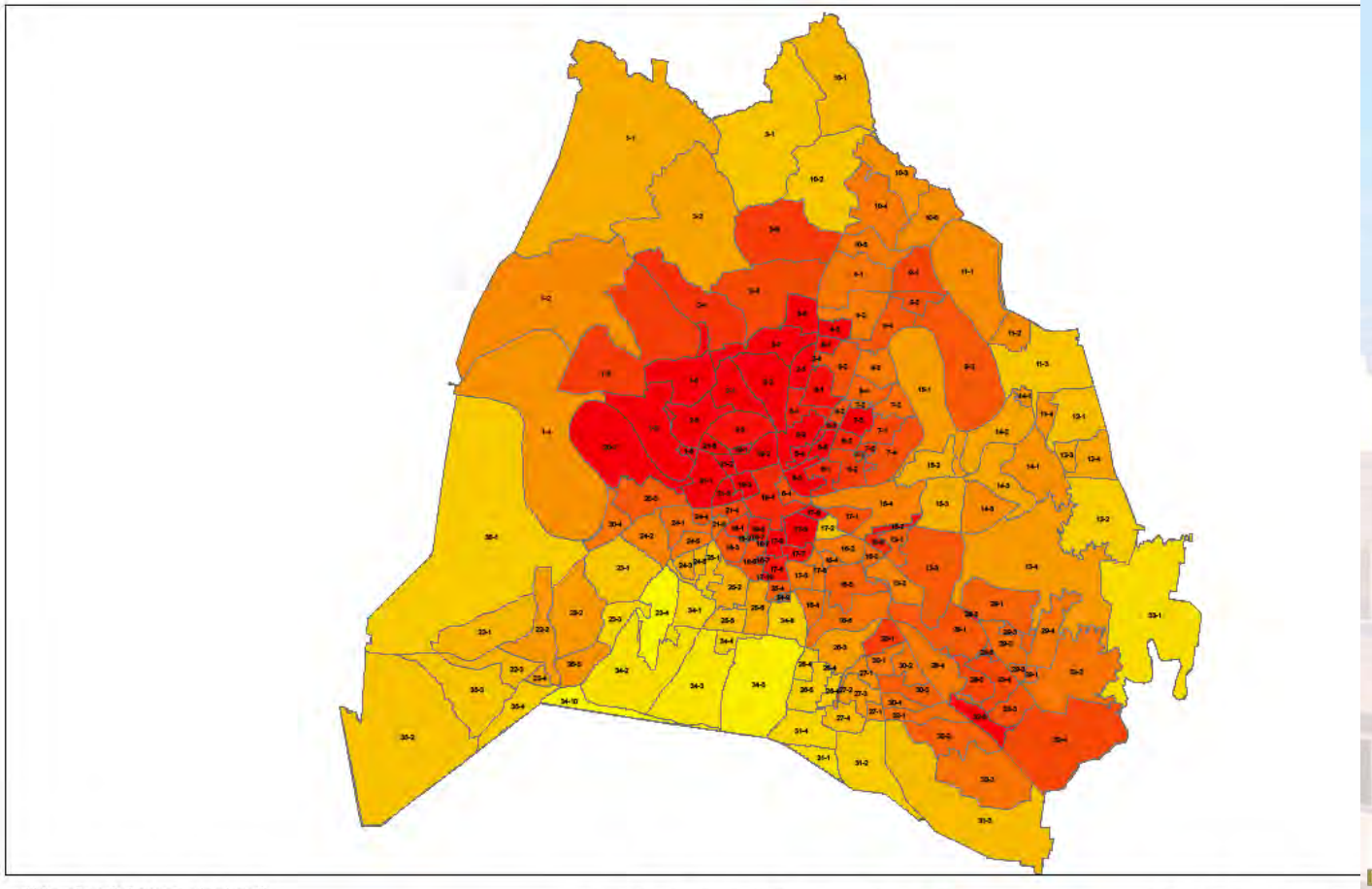
EPRI/TVA Distribution Impact Study 2009
Predicted Electric Car Penetration

Score Summary
Population Density

March 2009

Reliable Public Power Provider

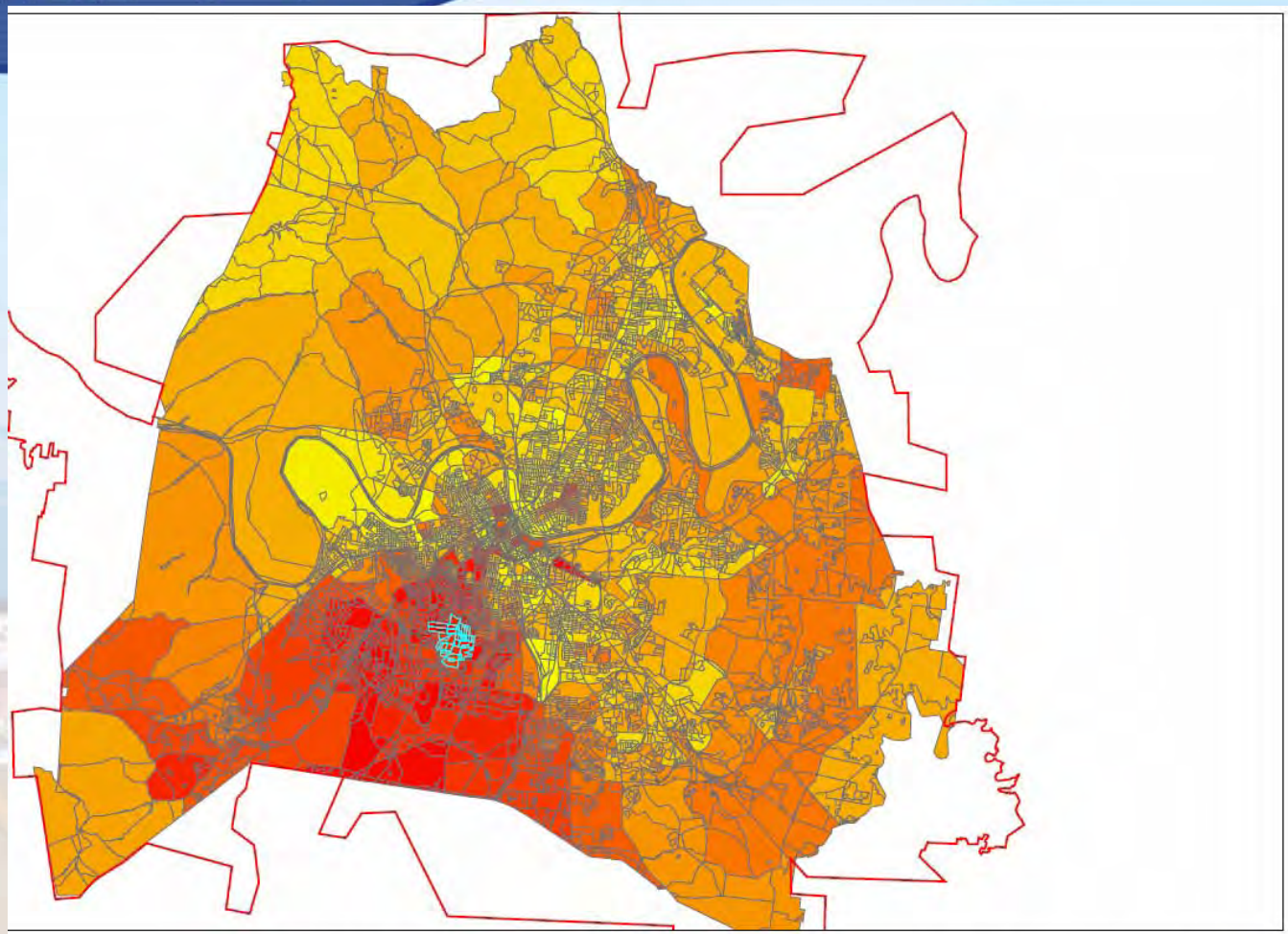
NES Service Area Voting Data



NES - Vanderbilt Study Project
Predicted Electric Vehicle Penetration

Score Summary
Politics by Voting Precin

NES Service Area Combined Scores



EPRI/TVA Distribution Impact Study 2009
Predicted Electric Car Penetration

Score Summary
Combined Factors

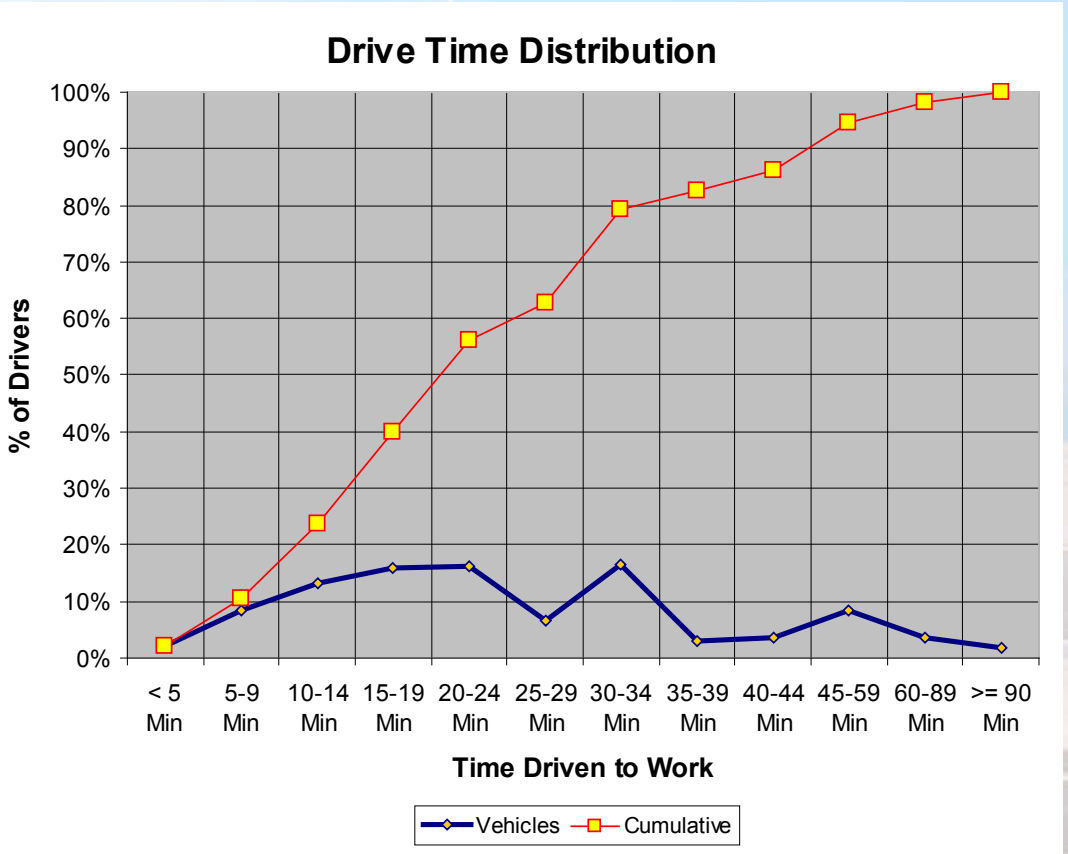
March 2009

Reliable Public Power Provider

Distance Driven When Arriving Home

- Overall driving patterns in the NES service area – 82% of drivers drive less than 40 minutes to work, 40% drive less than 20 minutes to work (1)

- People do not necessarily drive far enough to completely discharge their car battery



(1) Source: U.S. Census Data

Example Results for EPRI Utility Circuit

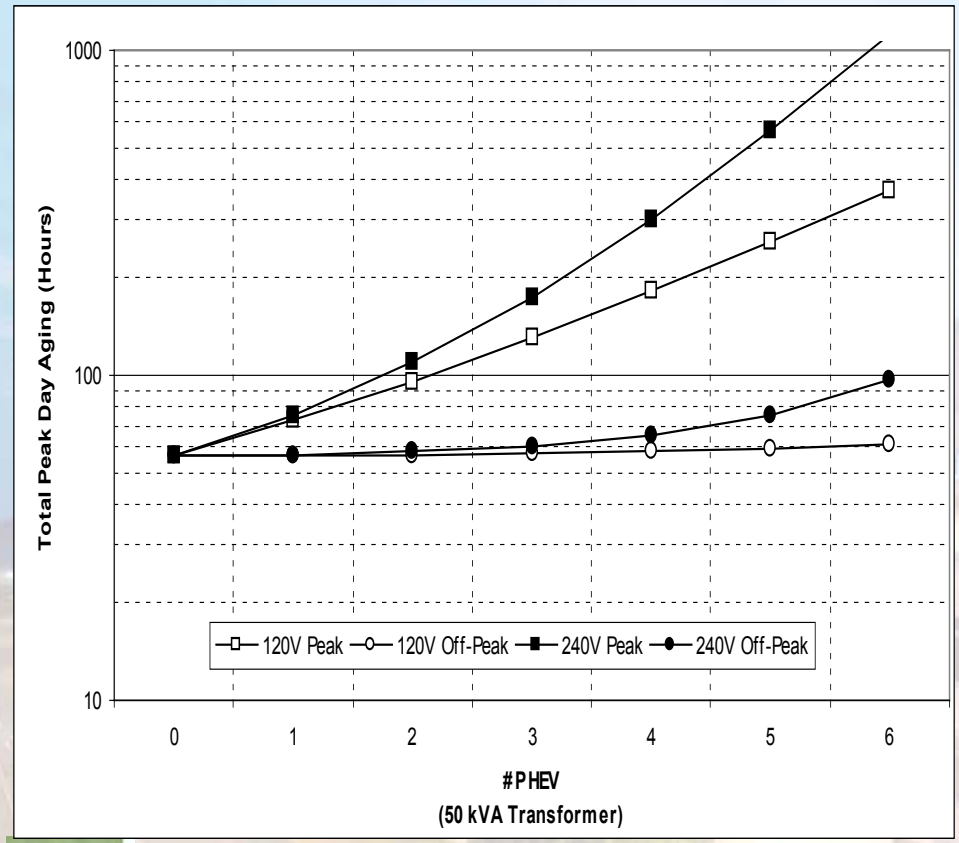
Line Xfmr Overloads - Component Deterministic Analysis

Smaller xfmrs sensitive to 240V charging, regardless of time.

	# PHEV	120V Peak	120V Off-peak	240V Peak	240V Off-peak
10kVA (1 Transformer)	1	0	0	1	1
	2	0	0	1	1
	3	0	0	1	1
25kVA (53 Transformers)	1	0	0	36	5
	2	0	0	46	38
	3	2	0	49	48
37.5 kVA (35 Transformers)	1	0	0	4	0
	2	0	0	18	1
	3	0	0	28	15
50 kVA (103 Transformers)	1	0	0	5	0
	2	0	0	24	0
	3	0	0	36	4
All Transformers (314 Transformers)	1	0	0	46	6
	2	0	0	89	40
	3	2	0	114	68

36 of 53 25 kVA xfmrs will exceed emergency rating for a single 240V PHEV charging at peak load hour

Transformer Aging can Increase Quickly



- According to a recent EPRI study, an increase of 33% in the total peak day aging is caused by:
  - peak ambient increased from ~ 95 °F to 100 °F
  - A single PHEV charging at peak
  - 9 Level 1 PHEVs concurrently charging at midnight
  - 5 Level 2 PHEVs concurrently charging at midnight

Reliable Public Power Provider

Nissan Leaf

- Approved for $1.6 billion DOE loan to retool and expand the Smyrna manufacturing plant to produce 150,000 zero-emissions vehicles and 200,000 battery packs annually beginning in late 2012

- The first EVs for the U.S. market will be available in 2010 and built in Japan
- All-electric vehicle (no internal combustion engine)
  - Lithium-ion battery technology with improved initial range of 100 miles before recharging, using electricity at a gasoline-equivalent rate of more than 350 mpg

RP3 Reliable Public Power Provider

Conclusions

- Electric vehicles will likely be concentrated in particular neighborhoods, i.e. clustering
- Problems will be highly localized and difficult to predict
- Distribution transformer failures will be very sensitive to deployment of PHEVs, ambient temperature, and any other parameter that affects transformer temperatures
- As battery technology improves, storage capacity will likely increase
- Level 3 Fast Charge may become the norm sooner rather than later

Reliable Public Power Provider

Music City Center

Music City Center

- Report recommending construction released February 2006
- Construction began on January 20, 2010
- Opening is scheduled for February 2013
- Approximately 350,000 sq. ft. exhibition hall, $585M cost
- Headquarters hotel construction to be determined at later date…

Music City Center
March 8

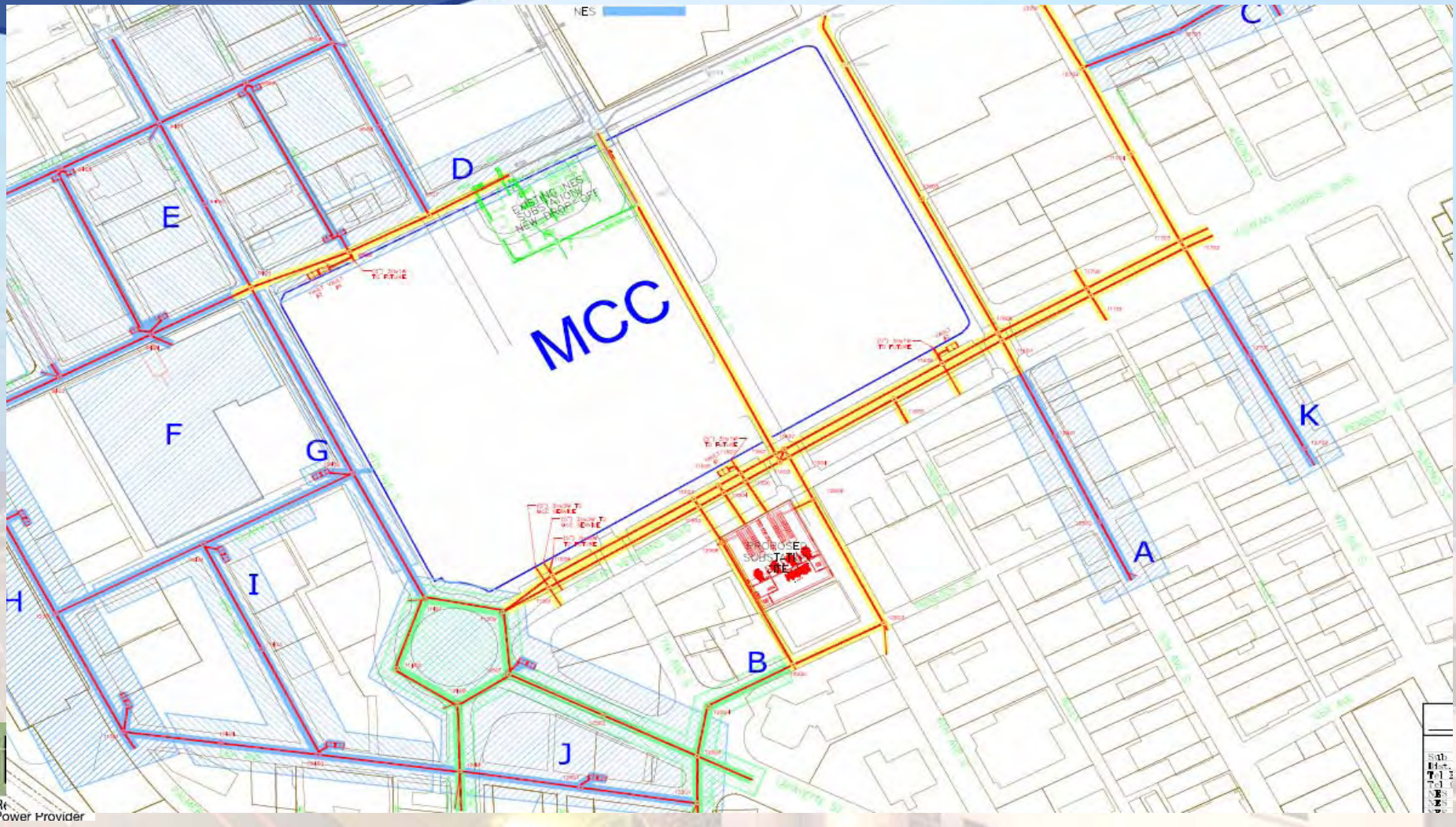
Music City Center
March 17

Reliable Public Power Provider

Music City Center
March 17

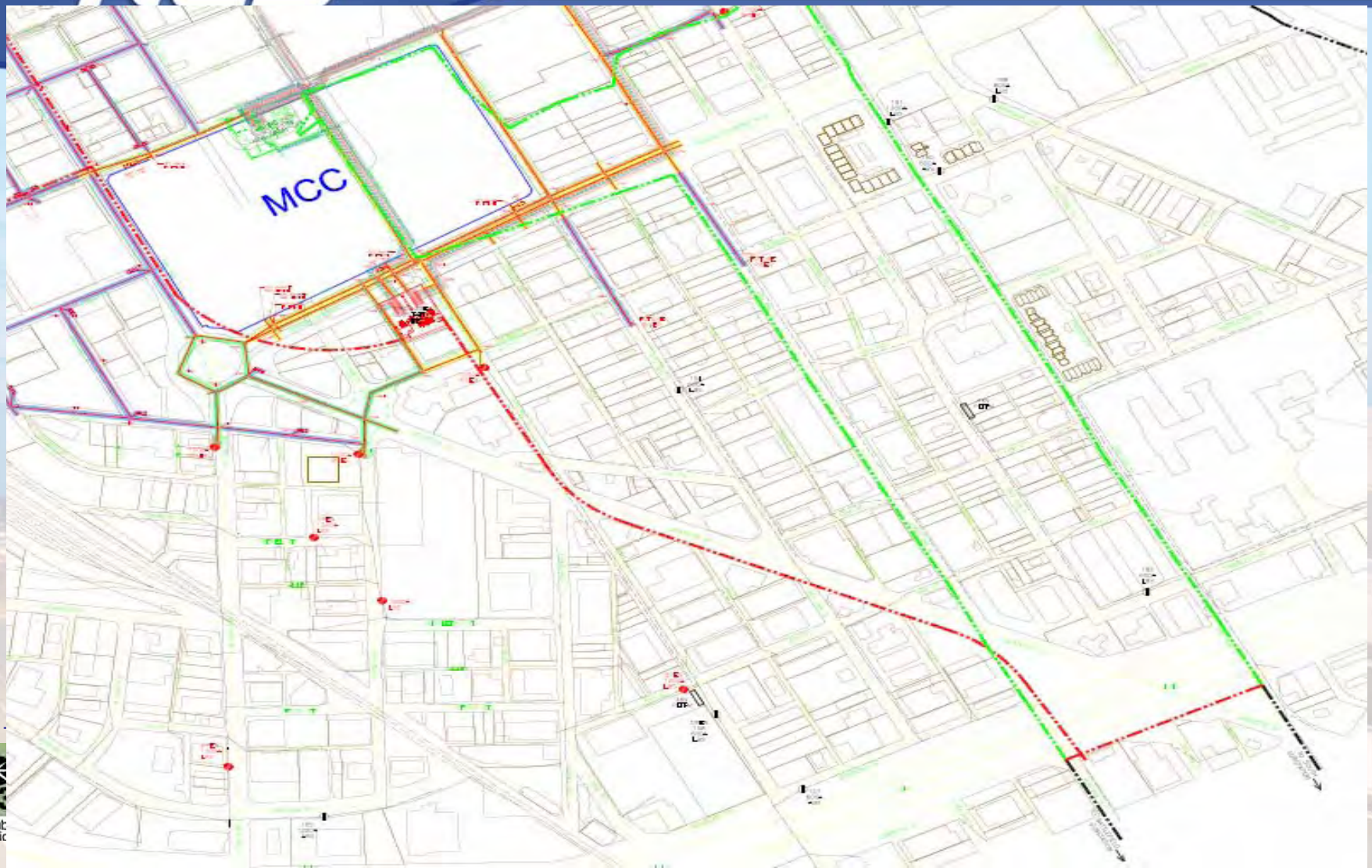
Music City Center
March 17

Substation & Distribution Relocation



Power Provider

Transmission Relocation



Transmission Tunnel

- Least Cost Option → approx. $7M tunnel cost
- 8.5 ft. Diameter, approx. 3,000 ft. in length
- Southern down shaft ~ 130 ft. at future substation
- Northern down shaft ~ 70 ft. at Peabody substation
- Construction time is estimated at 14 months (double shifts)
- Tunnel must be ventilated

- Two 1200 ampere 69kV circuits, fiber optic communication cable
- 1-2000 kcmil per phase per circuit, EPR insulation
- Cable to be purchased, cable installation RFP later this year
- Total time of installation (tunnel & cable) estimated at 18 months

Substation & Distribution Relocation

- Substation & Distribution relocation is on the critical path for completion of the Music City Center
- Construction of the new Peabody substation is scheduled to begin October 15, 2010 and completed by June 1, 2011
- Removal of the existing substation is scheduled to be completed by July 1, 2011
- Ultimate Substation configuration
  - 4- 40MVA 69kV-13.8kV power transformers, 24-15kV circuits
  - 69kV GIS ring bus, provisions for 4 transmission lines
  - Solid state relays and controls
  - Conversion of pilot wire underground network to relay based network
  - Cost is approximately $14 M
- Large single project in NES history, largest addition to underground network

Thank you and come back to Nashville again!