**IEEE P802.24**

**Vertical Applications Technical Advisory Group**

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# Background and Introduction

< to be merged in from the April, 2023 draft >

# Overview of AFV Fueling

< to be merged in from the April, 2023 draft >

# Deployment geographies (environments?)

< Subsection 1: A description of the sites where AFV Fueling is taking place. Attention will be paid to physical site characteristics that matter for network design, e.g. size and span (horizontal and vertical); connectivity to power systems and power density; physical security; brownfield vs. greenfield; etc.

Examples include

* residences (single- and multi-family);
* workplaces and other long-dwell, high-user-density sites;
* publicly accessible facilities for short-dwell, high-power-delivery “fast charging”, such as urban and suburban dedicated fueling stations, parking structures, and highway rest stops;
* fleet vehicle depots, including privately owned (goods delivery, taxi pools) and publicly owned facilities (school districts, postal services,
* highway-side fueling facilities for extremely-high-power-cleivery long-haul truck re-fueling (“truck stops”) >

< to be reconciled with content from the April, 2023 draft >

# AFV Fueling Use Cases

## Smart Home and Cooperative Energy Management

< Note: order of the Use Case sub-sections and their numbering might change. >

This Use Case focuses on EV charging in residential and small building (perhaps, multi-family residential and small-to-medium sized business office) geographies.

### Electrical characteristics of residential/small building charging

Currently, the most common type of EV charging used in these sites is a so-called “Level 2” (L2) AC charging device. Level 2 designates the capability to deliver 3-20 kW of power to recharge the EV battery; this is done by a control unit (integral to a “cordset” that plugs into a standard electrical socket, or to a fixed-in-place “wallbox” with a receptacle or cable and connector) that among other things, manages energy flow to the on-vehicle converter and battery management system. The voltage level of L2 charging is 200-250 VAC; and the current level typically ranges from 12-80 Amps. L2 charging service is defined in three standards: SAE J1772 (used in North America and Japan); GB/T-XXXX (used in China); and IEC 68151-1 (used in Europe). While there are substantive difference between the three, they have much in common.

The SAE J1772 standard defines charging using a single-phase electrical connection; the connector it defines has three pins to support power transfer: two for power delivery and one for earth (ground). Two additional, smaller pins are used for control pilot (signaling) and proximity sensing (optional).

SAE J1772 also defines “Level 1” charging, which uses 100-120 VAC. [need to check L1 current range] Most legacy North American EVs support L1 charging over a cable with a three-prong (grounded) household appliance plug on one end and a J1772-compliant connector on the other. Newer EVs, especially those with battery capacity of 30 kWh or more, might not support L1 charging due to long charging times at L1 power levels (see below).

The IEC 61851-1 standard defines charging using both single- and three-phase electrical connections; consequently, the associated connector (per IEC 62196-2) has five pins for power transfer: three for power delivery (one per phase; single-phase charging is supported on two designated pins) and one for earth (ground). Like the SAE standard, two additional pins are used for control pilot and proximity sensing / resistive coding.

The advantage of L2 charging is shorter EV charging times. For example, fully charging an EV with 30 kWh battery capacity would take more than 15.5 hours to charge at L1 (~2 kW: 120 VAC x 16 A) and fewer than 4 hours at a typical L2 level (~7.6 kW: 240 VAC x 32 A). Using four times the power, the EV can charge in 1/4 the time.

Note that the amperage values above align with common circuit breaker values, and a North American electrical code requirement that breakers be rated to trip at 125% of the maximum expected current draw (appliance maximum current rating) on the circuit. A charging device drawing up to16 A requires a 20 A circuit breaker; a 32 A device is protected by a 40A breaker.

The main deterent to L2 charging is the potentially high cost of providing the electrical wiring and protection needed. The worst case is when the capacity of the site’s electrical service would be exceeded by the addition of an EV charging station; the cost of a utility service upgrade (say, from 100 to 200 A) can be prohibitive. Another consideration is whether existing wiring from the service delivery point (the circuit breaker box) to the installation location is adequate; if not, new wiring might need to be installed. Finally, the cost of the EV charging device adds to the overall impact, but this is often the least costly part of a project.

### Communications aspects of residential/small building charging

Since L2 AC charging is controlled by analog circuits in the charging device and the EV, which are connected by the charging cable, there has been no need for communications interfaces on either to support the charging function. Nevertheless, some vendors have included wireless communications capabilities in their wallbox products to provide user access and some services. Examples include Bluetooth™ for charging station configuration using a vendor-provided app on the user’s smartphone; and Wi-Fi® for communication between the charging station and the vendor’s cloud-based charging network (and device) management system, via the user’s home Wi-Fi AP/router and Internet access (e.g. via cable or DSL modem).

An example of a service delivered to the charging device via Wi-Fi and the vendor’s cloud, is to allow the user to select their electricity pricing rate program from a list provided by the utility or utilities serving their location. Some utilities offer discounted rates for overnight consumption, encouraging EV charging at lower cost when electricity is not in high demand. If the user enrolls in such a program and selects that rate, their wallbox might be configured to block charging, or post a warning, if the EV is plugged in when rates are higher (e.g., during daytime). Given the rate program, the wallbox could calculate and display the cost of charging the EV. (Only after energy has been delivered, unless the EV’s battery capacity was set on the station and the EV sent its state of charge before charging, which is not currently possible using SAE and IEC L2 AC charging protocols).

A similar service that could be provided to EV drivers via the vendor cloud and Wi-Fi include charging power level regulation and/or incentive based on energy pricing or utility capacity constraints. Thus, an attempt to charge an SUV or pick-up truck with a 120 kWh battery pack at 14.4 kW (60 A) during hours of peak energy demand might result in the charging station being limited to delivering only 7.2 kW (30 A) and perhaps incentives – a price discount or confirmed reservation – to charge at a nearby public fast charging station that gets its energy from solar panels and energy storage, rather than the grid.

< an example in multi-family dwellings: ‘waitlist’ queueing with notifications when charging stations become available; note: this uses NFC/M2M/cloud/app but not 802 comms, in a non-trivial way >

Such EV charging services use IEEE 802 communications (Wi-Fi) in a limited way, and depend on the device vendor (or service provider) and utility to partner on providing service offerings. Developments in Smart Home promise to expand opportunities for EV charging to participate in comprehensive, dynamic *cooperative energy management*.

### Smart Home platforms for Cooperative Energy Management

The term ‘Smart Home’ designates a system that coordinates and controls services in a single- or multi-family dwelling, such as HVAC, lighting, media and information, security, water, and distributed energy resources (DERs) including rooftop solar, fixed energy storage, and electric vehicle charging/discharging. The goals of such a Smart Home system are to enable constituent devices and systems to respond to user requirements and desires, while also optimizing as much as possible the use of resources, in particular electrical energy.

In order to meet these goals, the devices and systems in a home need to have some degree or information processing and communication capability. Modern media devices, which are highly configurable and connected, provide a good example of how any subsystem within the home can be automated and integrated with others. For example, meshed Wi-Fi nodes – originally meant primarily to provide consumer devices with wireless access to the Internet –now incorporate microphones and speakers, allowing for natural-language interaction from almost anywhere in the home; can retrieve or relay data such as music playlists or television viewing preferences and activate services accordingly; and can report the status or change the settings of environmental controllers such as thermostats, skylights, and window shades. One can imagine such nodes soon incorporating sensors to gauge environmental factors (e.g. air quality, human/pet motion/activity, light or noise levels) as well.

A vital area of research and development is home energy management. As home energy becomes more electrified (due primarily to environmental benefits), there will be opportunities to balance convenience and environmental preferences with energy efficiency. And as users’ expectation for convenience – the ability to view and change settings from anywhere – grows, appliance vendors will likely need to expose more and better communications and control interfaces that can be leveraged for integrated smart home management.

Examples of this evolution include the Matter protocol, which has emerged as a foundation for a comprehensive Smart Home ecosystem. EMAP, another vision for next-generation Smart Home integration, is provided in the ISO/IEC 15067-3 series of standards. IEEE 2030.5, the successor of the ZigBee Alliance’s Smart Energy Profile 2.0, is a “standard for communications between the smart grid and consumers … built using Internet of Things concepts”. All of these can be deployed on IEEE 802 (Wi-Fi, Ethernet, 805.12) networks.

*Figure N: Examples of Smart Home platforms that can be deployed on IEEE 802 networks*

IPv4/IPv6

UDP

CoAP

EMAP

Applications

#

### Integrating EV charging in an EMAP network

< team KOR – please expand on this! >

