Overview of standards for EV charging

ASPROM, 17/11/2011

AGENDA

- Physical connectors
- Current state of standardization
- IEC 61851
- J1772 – J2847
- IEC 15118
- SEP 2.0
- The overall ecosystem

« Old » connectors

National standards:

- USA: SAE J1772 or IEC 62196-1 (single phase)
- Germany: VDE-AR-E 2623-2-2/Mennekes
- Japan: JARI/TEPCO or IEC 62196-1
- Europe/China: IEC 62 196-2, 62 196-3 or 60309

IEC 60309-2 3P+N+E

New connectors

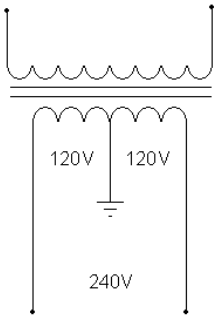
- US, Japan : J1772 2010 plug (5 pins, single phase)
  - In practice virtually all new vehicles : Chrysler, Ford, GM, Honda, Mitsubishi, Renault-Nissan, Tesla, Toyota
- Europe :
  - Type 1 = J1772. *250 V, 32A. Up to 7 kW (full charge in 4 to 6 h, or 50 to 70 km per hour of charge).*
  - Type 2 (= Mennekes)
    1 or 3 phase, < 500 V, <63 A (<70 A for 1 phase).
    3 phase/400 V/32 A = 22 kW = 100 to 150 km per hour of charge.

Type 2 connector

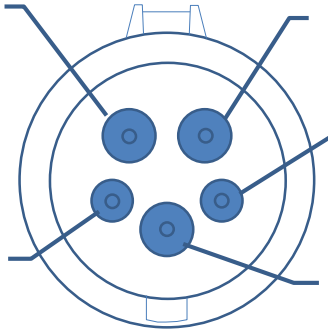
SAE J1772:2010

Single phase

3 dedicated comm. pins of J1772:2001 removed



Typical US wiring



The proximity detector pin is connected to the ground via a resistor network in the plug, the resistor value changes when the latch release switch of the plug is pressed, signaling that the plug is about to get disconnected

EVSE side plug (« type 3 »)

- Need to adapt to various neutral regimes in Europe
- Promoted by EVplug alliance

Quelques ordres de grandeur

		PHEV15	PHEV40	BEV
Battery capacity (kWh)		5	16	24
Charging time (20% to 100%)	1,4kW (16AWG)	2h50mn	9h10mn	13h45mn
	3,3kW (16AWG)	1h15mn	3h50mn	5h50mn
	7kW (8AWG)	35mn	1h50mn	2h45mn
	19,2kW (8AWG)	15mn	40mn	1h
	60kW (4AWG)	5mn	15mn	20mn
Charge depleting range or All Electric mode range		23km – 15 miles	64km – 40 miles	160 km – 100 miles

AGENDA

- Physical connectors
- Current state of standardization
- IEC 61851
- J1772 – J2847
- IEC 15118
- SEP 2.0
- The overall ecosystem

IEC 61851/J1772 pilot wire

- Early EV chargers relied only on traditional 30 mA differential circuit breakers to detect current leakage.
- Modern EV chargers must have a dedicated pilot wire, which conforms to IEC 61 851:2010 (*Electric vehicle conductive charging system –Part 1: General requirements*), which implements proactive mass defect detection.

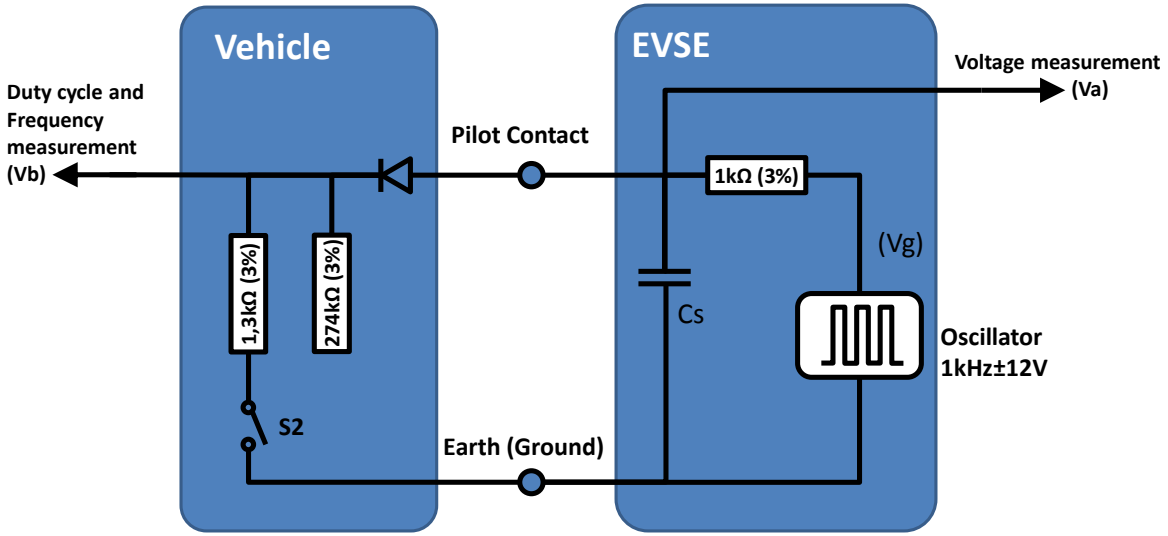
PWM basic charging power control

- IEC 61 851:2010 specifies a simple pulse width modulation (PWM) protocol on the pilot wire enabling the EVSE to communicate to the EV the maximum charging current allowed.
- The initial idea was to make sure that the EV would never draw excessive currents capable of causing fires in the charging infrastructure, but the mechanism can also be used for **admission control and demand response**.
- **Fi**

Pilot wire operation

- EV ready → close S2
- EVSE duty cycle indicates the maximum current that the EV is allowed to draw from the EVSE

- <3% no charging
- 8-100% : 6-80A
- 5% : high level communication



Bidirectional charging control (DC charging)

- Communication by the EV to the EVSE of EV requirements related to the charging of the EV battery by an external CC charger: like the constant current, constant power or constant tension required (depending on the battery technology).
- There are no agreed international standards yet at this level, IEC 61851-23 was not published as of March 2011. The de-facto standard for existing vehicles is CHAdeMO, which uses dedicated pins on the J1772 connector.

High level communication

- Charging control, security, charging and potentially many other services.
- There are two standardization tracks:
  - ZigBee SEP 2.0
  - IEC 15118 (*Road vehicles - Vehicle to grid communication interface*).
- At the physical level, the proposals are to use IPv6 on top of Homeplug Greenphy.

AGENDA

- Physical connectors
- Current state of standardization
- IEC 61851
- J1772 – J2847
- IEC 15118
- SEP 2.0
- The overall ecosystem

IEC 61851 scope

Managed by IEC TC 69. IEC 61851 is split in several documents:

- Part 1: General requirements
- Part 21: Electric vehicle requirements
- Part 22: a.c. charging station requirements
- Part 23: d.c. charging station requirements
- Part 24: communication protocol

Charging mode 1

- Standard 16A socket outlet, single phase or 3-phase.
- The protection against electric shock relies only on differential breakers in the charging infrastructure or in the cable.
- This charging mode is *prohibited in the US*, but outside of the US most EVs currently circulating use mode 1 charging.

Charging mode 2

- Standard 16A or 32A socket outlet on the charging infrastructure side, but uses a specific plug on the EV side.
- The **cable must include a protection device which implements proactive current leakage detection** through the pilot wire.
- This mode is the default for newer EVs in the US and Japan (the J1772 plug is used on the EV side), and is available as an optional cable for most never EVs in other countries.

Charging mode 3

- Requires a dedicated EVSE which manages the pilot wire
- The plug is energized only if all of the following conditions are met :
  - The vehicle power plug is totally inserted (the pilot pin is last to connect)
  - Ground continuity has been checked (pilot current present)
  - The vehicle has transmitted a signal confirming that everything is secured and charging is ready to begin.

Charging mode 4

- **Mode 4** applies to external chargers (e.g. DC charging) and covers also the inverse mode where the EV provides power to the charging infrastructure.
- This mode, covered by IEC 61851-23, is not fully specified yet. It requires a serial bidirectional communication over the pilot wire.

AGENDA

- Physical connectors
- Current state of standardization
- IEC 61851
- J1772 – J2847
- IEC 15118
- SEP 2.0
- The overall ecosystem

Charge levels

- ‘Level 1’: charge via a charge cable including the pilot wire control equipment (« mobile EVSE »), connected to a US domestic plug (single phase 120V/15-20A).
- ‘Level 2’: charging via a fixed EVSE station connected to a 240V single phase, up to 80A.
- ‘DC charging’, using an off-board charger.

J2847

The J2847 series is the result of joint work since 2009 between SAE and the ZigBee and HomePlug alliances, with the following objectives:

- Defining a message set that would support the requirements of J2836/1
- Integrate with Home area Networks and Utility networks
- Follow the REST model recommended by the NIST, and be based on IPv6.

→ Basically an extract of ZigBee SEP 2.0

AGENDA

- Physical connectors
- Current state of standardization
- IEC 61851
- J1772 – J2847
- IEC 15118
- SEP 2.0
- The overall ecosystem

IEC 15118

"*Road vehicles - Vehicle to grid communication interface*"

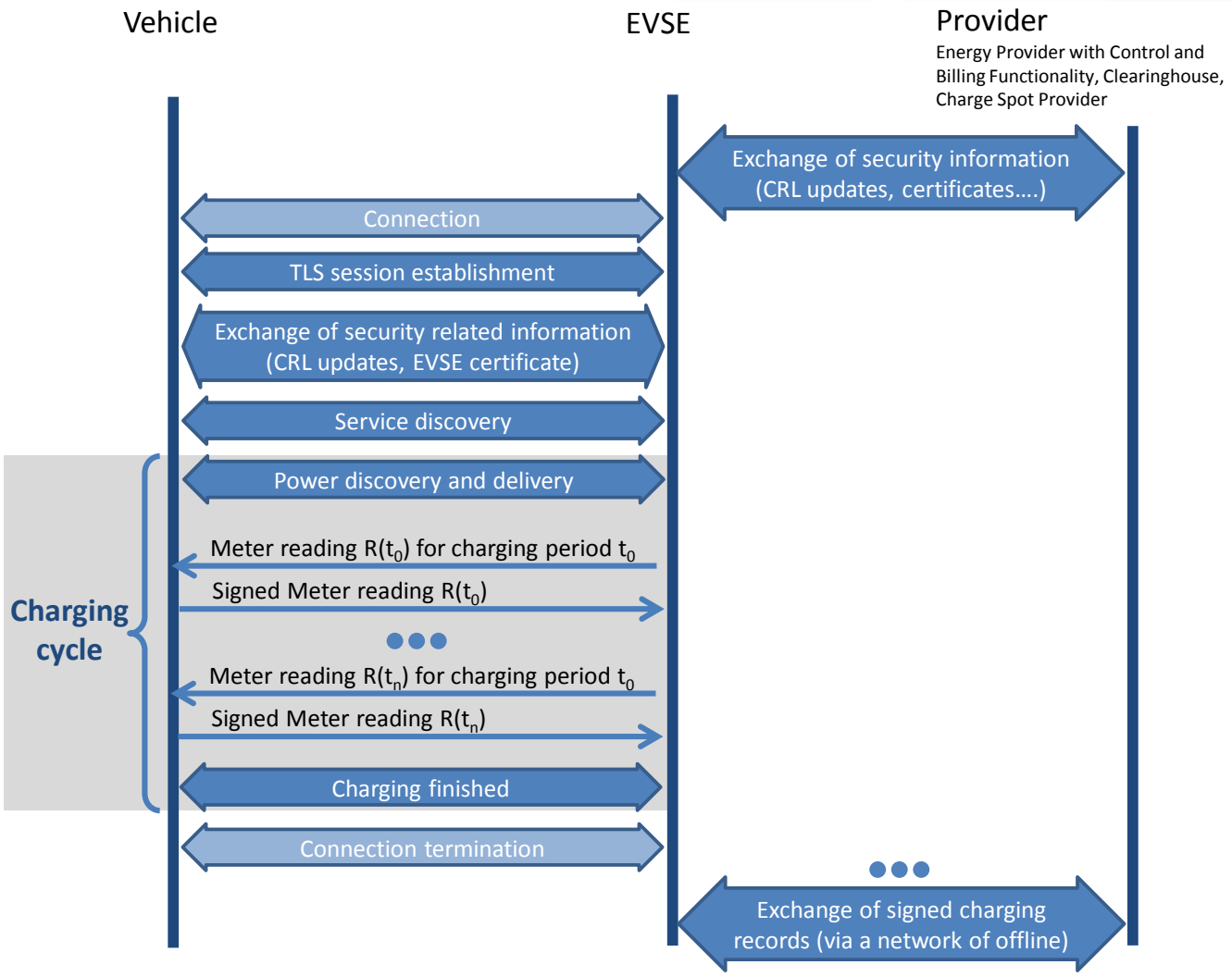
- Still a work in progress at the time of writing.
- This standard is managed by ISO/TC 22 (Road vehicles) jointly with IEC TC69.
  - Part 1 : Vocabulary
  - Part 2 : Description of Vehicle to Grid Transfer Protocol (V2GTP)
  - Part 3 : Physical layer

Service discovery

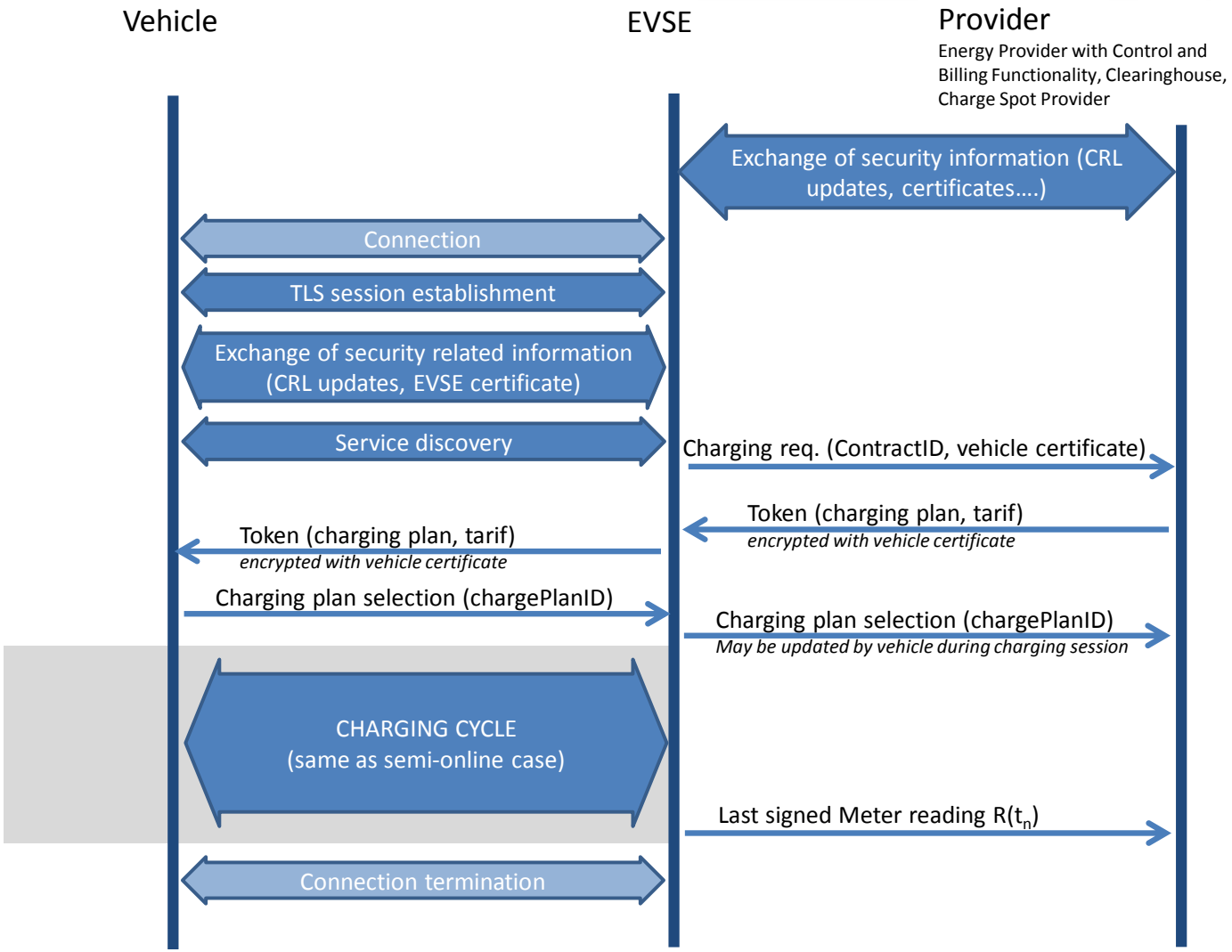
- SECC Discovery Protocol (SDP)
- The EV multicasts a UDP_SECC_LISTEN message to port 15118 (!)
- The EVSE generates a random sessionID or provides the last valid sessionID if this is an attempt to resume a session. The SECC*, if any, will respond to the source UDP port with a SECC discover response message, which specifies the server side TCP port for the V2GTP session.

(*) supply equipment communication controller

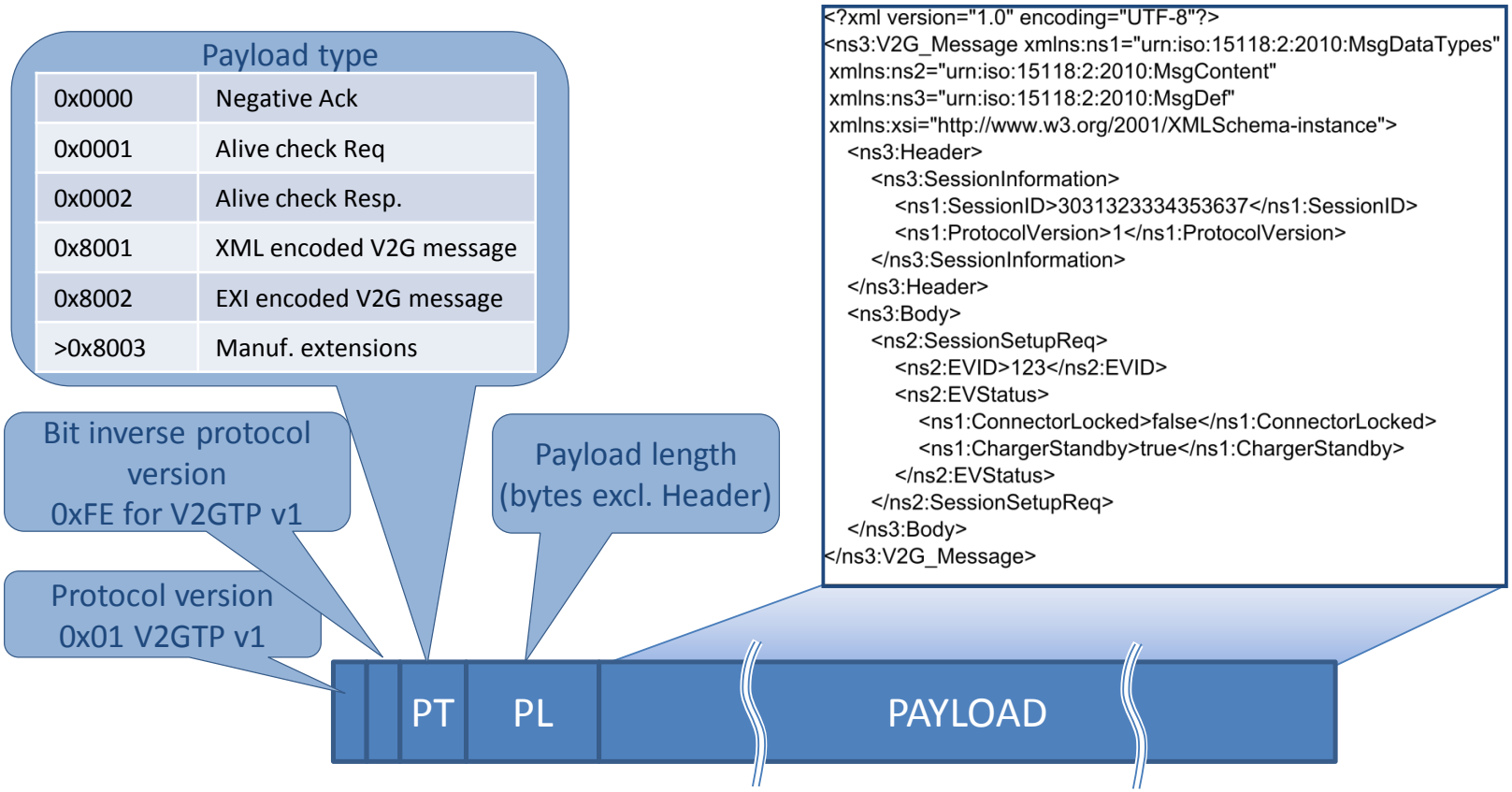
Charge session overview : semi-online



Charge session overview : online



V2GTP PDU structure



Initialization of communication session

After session bootstrapping with the SECC Discovery Protocol and TLS session setup, the following messages are exchanged:

- **SupportedAppProtocolRequest/Response** : EVSE and EVCC supported protocol versions, associated namespaces and preference order.
- **Session Setup Request/Response** : The plug-in EV (PEV) specifies the PEV MAC address (PEVID) and PEV status code. The EVSE replies with a response code, an EVSEID and status code.

Service Discovery (1)

Discover the services offered by the EVSE.

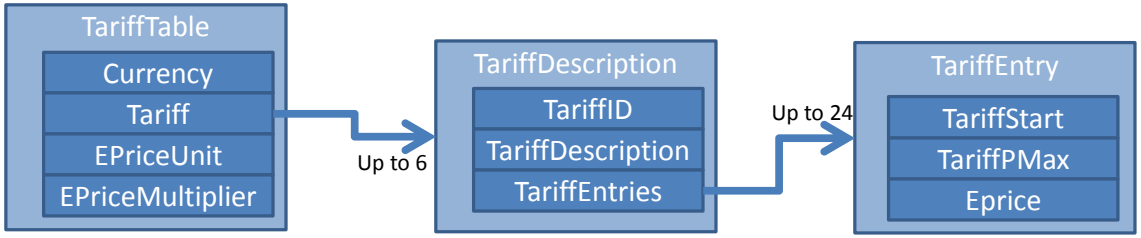
- Service Discovery Request/Response:
  - Request specifies service scope (one or more URIs , each corresponding to a service provider), and optionally service type (e.g. charging, internet access).
  - EVSE response specifies a list of supported services.
- Service Selection Payment Request/Response:
  - Request: EV selects services and corresponding payment options in the Service Selection Payment Request
  - EVSE validates each service/payment option selected.

Service Discovery (2)

- Payment Details Request/Response:
  - So far only the details corresponding to payment method “contract” are specified.
  - The EV sends a contractID, and the signature certificate chain of the EV.
  - The EVSE responds with a random challenge which has to be signed by the EV.
- Contract Authentication Request:
  - The EV sends a copy of the challenge and its signature, and the EVSE answers with a response code.

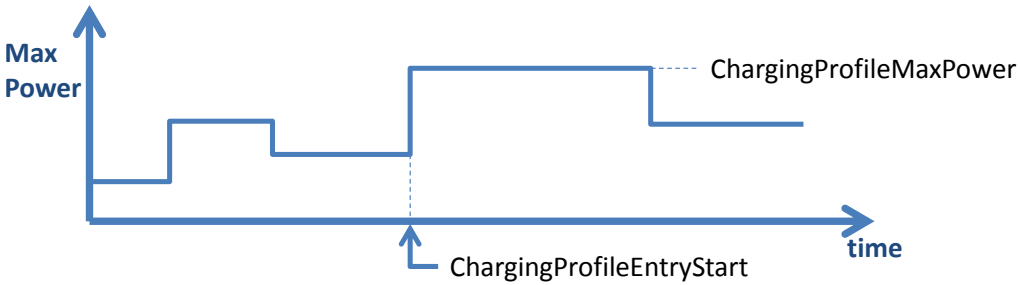
Charge service : 1/ Setup

- Charge Parameter Discovery Request/Response:
  - EV provides status information, charging mode (DC or AC), desired point in time for the end of charge, estimation of required recharge energy , maximum charge power, max/min charge voltage, max number of charge phases, max/min charge current.
  - EVSE responds with its status information and provides its own charging limit parameters, as well as the identity of the relevant Mobility/Energy provider and a Tariff table



Charge service : 1/ Setup

- Line Lock Request/Response
- Power Delivery Request/Response
  - EV requests the EVSE to start providing charging power, specifies the selected tariff and optionally transmits the estimated charging profile it will follow during the charging process.
  - EVSE replies with a response code and capacities



Charge service : 1/ Setup

- Metering Status Request/Response:
  - EV requests EVSE to send its current metering status.
  - EVSE response contains a timestamp, an instantaneous estimate of the power the EVSE could deliver, optionally the current power it is delivering, a meterID and current metering information.
- Metering Receipt Request/Response:
  - Request contains the electronic signature of sessionID, MeterInfo, PEVstatus, time stamp, tariffID, metering information.

Charge service : 2/ Charging process

Periodically (~10s):

- Metering Status Request/Response and Metering Receipt Request/Response

if needed

- Charge Parameter Discovery Request/Response and Power Delivery Request/Response

Charge service : 3/ End charging

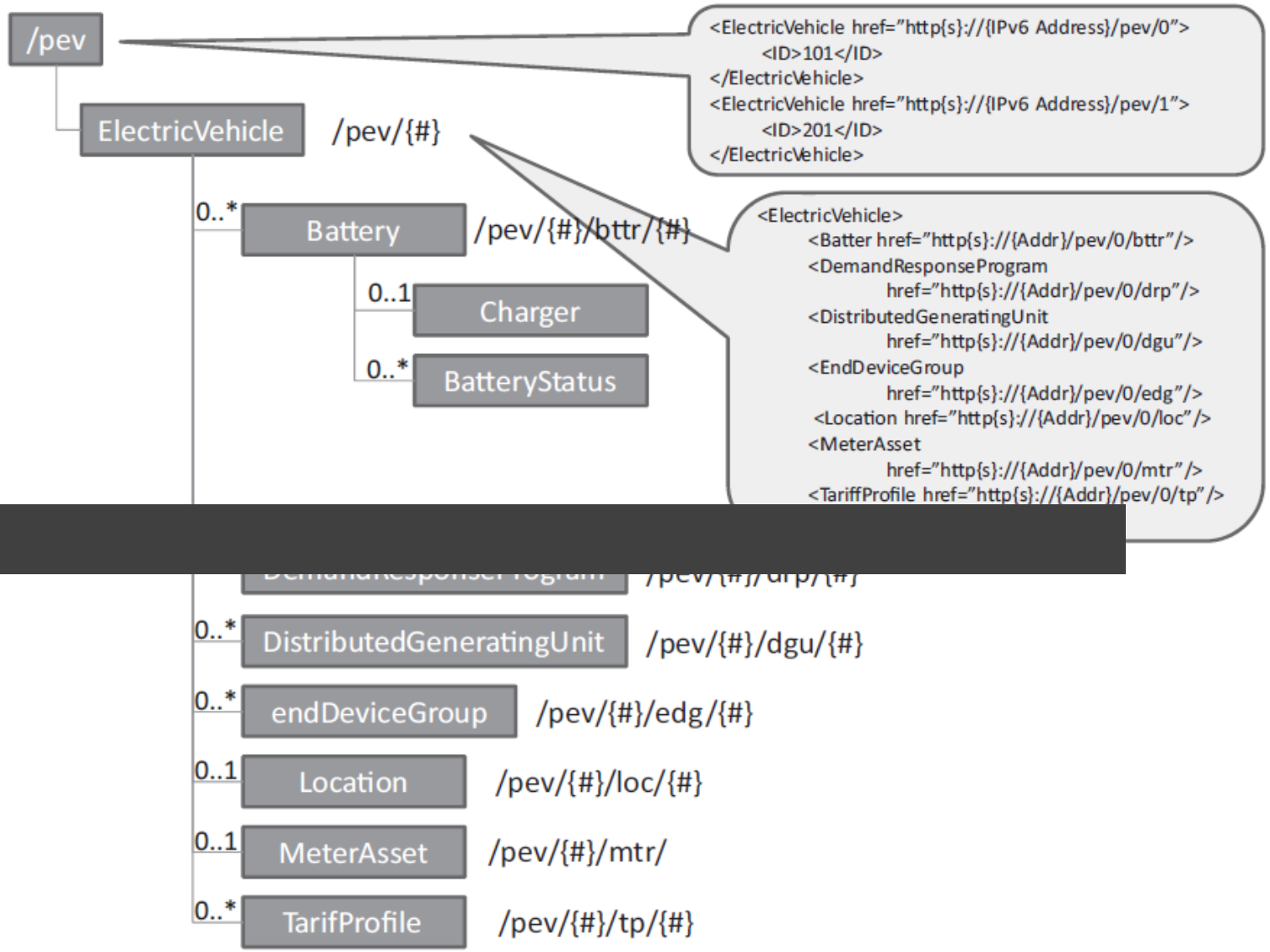
Finalise charging process:

- final Power Delivery Request/Response, Metering Status Request/Response, Metering Receipt Request/Response)
- unlock charge cord with Line Lock Request/Response

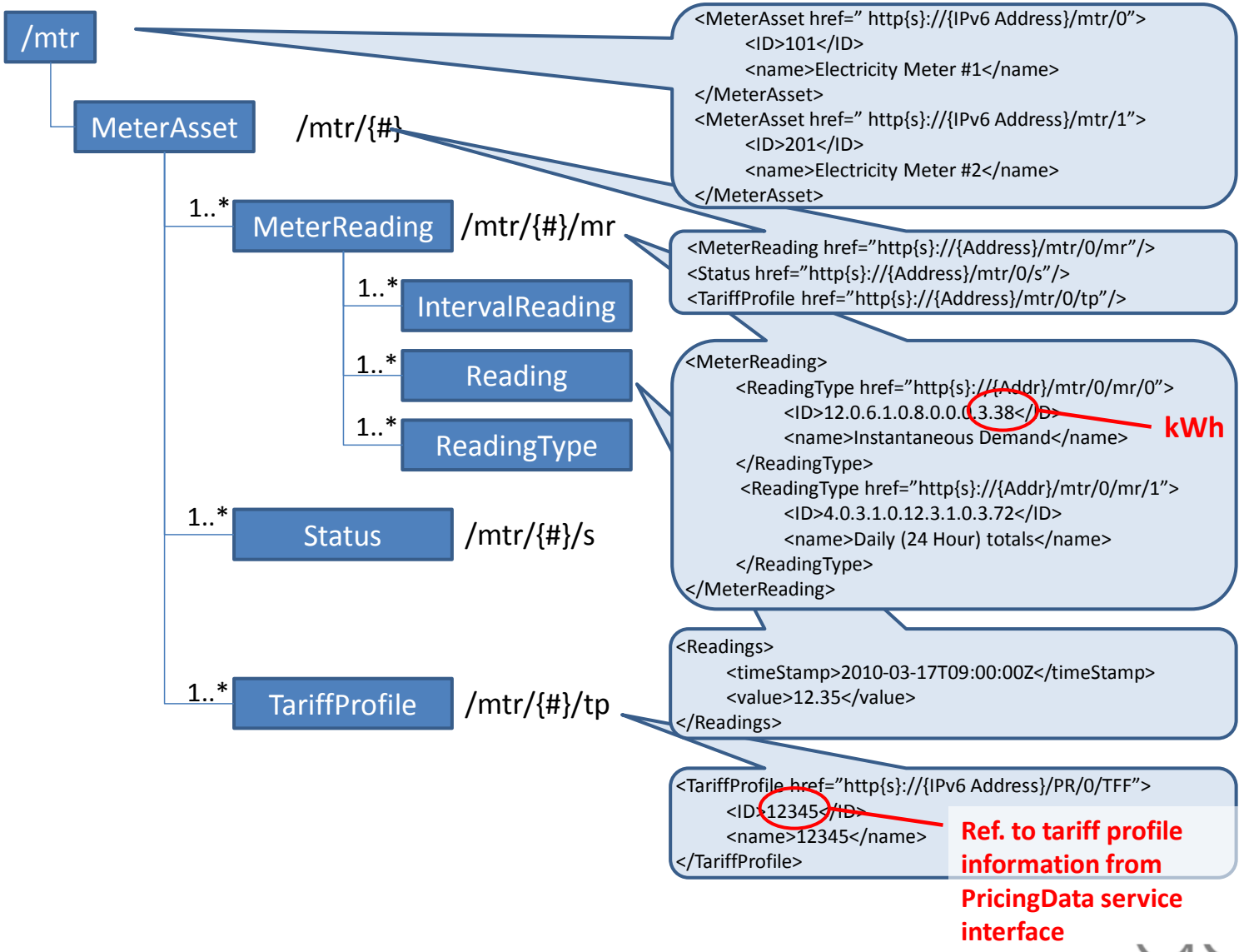
AGENDA

- Physical connectors
- Current state of standardization
- IEC 61851
- J1772 – J2847
- IEC 15118
- SEP 2.0
- The overall ecosystem

/pev resource



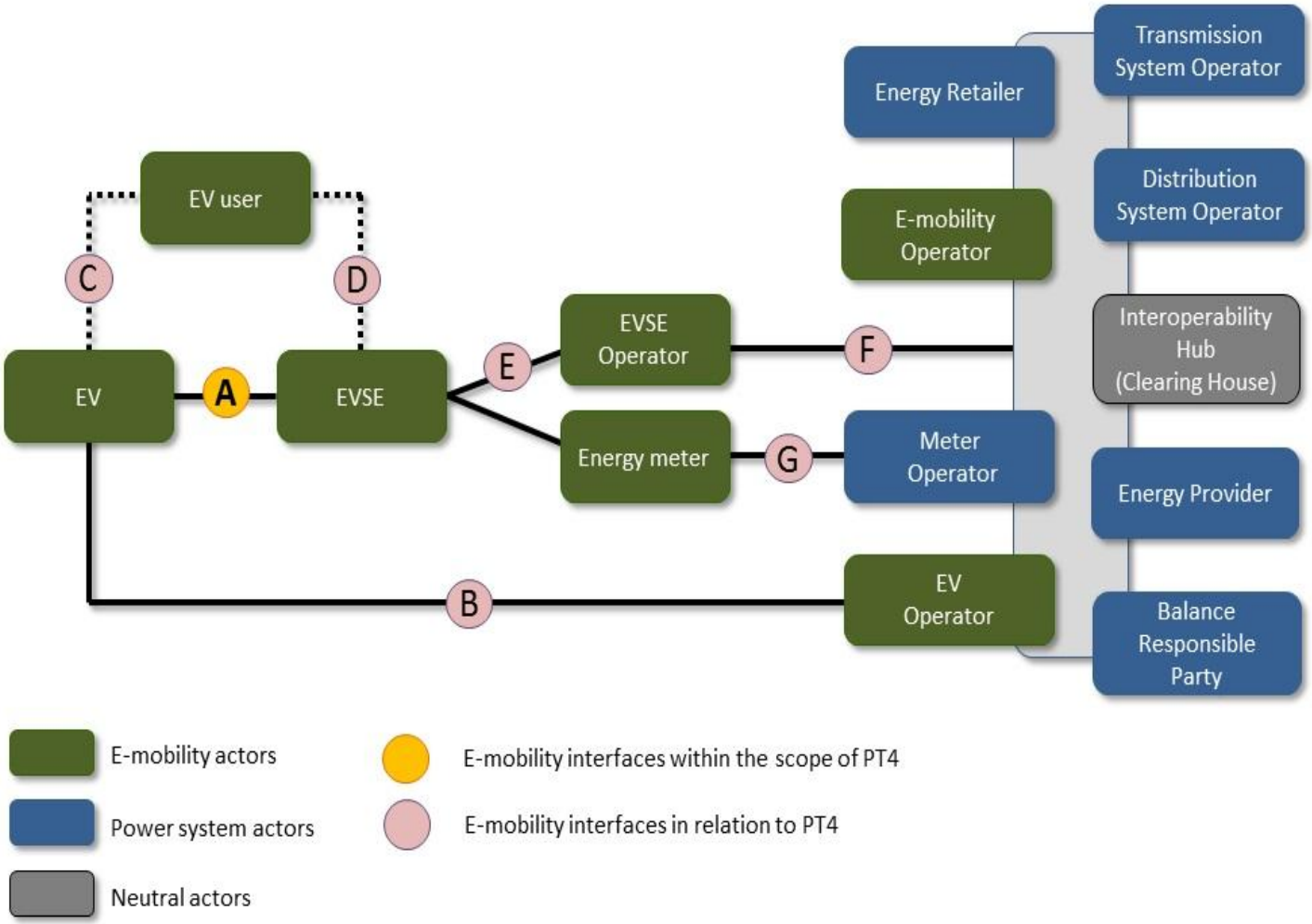
/mtr resource



AGENDA

- Physical connectors
- Current state of standardization
- IEC 61851
- J1772 – J2847
- IEC 15118
- SEP 2.0
- The overall ecosystem

CENELEC PT4

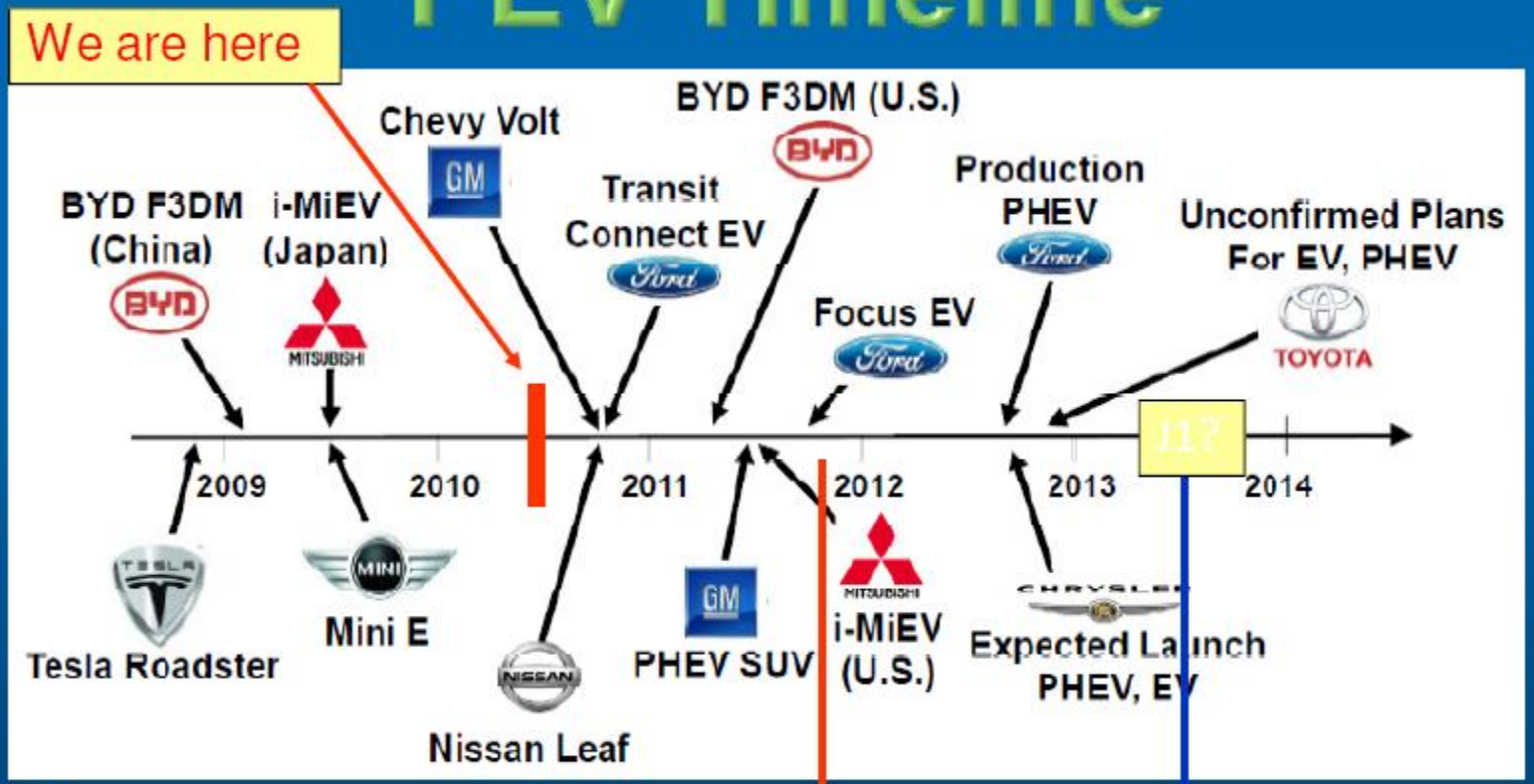


Acteur	Problématiques
Opérateur local de recharge	Identification des contrats liés aux sessions de recharge, authentification, récupération d'éléments de profilage (e.g. priorités), éléments liés à la facturation (identité du payeur, plafonds d'autorisation), mise à disposition d'une interface en vue du pilotage en ajustement du véhicule, redistribution des dépenses en contexte de recharge sur compteur collectif, valeur métrologique des sous-comptage, justifications portant sur l'origine de l'électricité consommée. Contrôle d'admission local.
GRD	Contrôle et prise en compte des sous-comptages, en vue de la production des données, requises par les contrats de fourniture d'électricité et de RE, liée à la recharge des VE (profilage, origine de l'électricité consommée), de l'attribution du bon périmètre d'équilibre aux tickets de comptage, de la correction des consommations des compteurs principaux, de la prescription d'ajustements sur des critères locaux (pointe de réseau, équilibre local production/consommation), de la vérification des ajustements. Contrôle d'admission au niveau régional.
GRT	Gestion des périmètres nationaux d'équilibre associés aux opérateurs de recharge. Vérifications sur la nature de l'énergie consommée. Vérifications des ajustements.
Opérateur de mobilité	Identification des contrats liés aux sessions de recharge, authentification, contrôle d'admission. stipulation d'éléments de profilage (e.g. priorités), éléments liés à la facturation (identité du payeur, plafonds d'autorisation). Si roaming de l'électricité, rattachement des profils de recharges à son contrat d'achat global d'électricité, justifications portant sur l'origine de l'électricité consommée.
Fournisseur d'électricité	Gestion de l'équilibre P=C sur son périmètre. Authentification des profils de consommation de ses clients. Facturation. Justifications portant sur l'origine de l'électricité consommée.
Acteurs d'ajustement nationaux	Pilotage et vérifications des ajustements sur des critères nationaux (pour le compte du GRT).
Acteurs d'ajustement régionaux	Pilotage et vérifications des ajustements sur des critères régionaux (pour le compte du GRD).
Constructeur, etc.	Mise à disposition d'éléments d'information enrichis permettant un meilleur pilotage de la session de recharge, typiquement par GPRS.
Services généraux	Gestion du contrat de fourniture d'électricité global, vérification de la redistributions aux usagers (sous comptage) et du décompte des services généraux (compteur primaire)

PLUG-IN 2010

SAE International

PEV Timeline



Plan B

Test and Selection Process

Implement

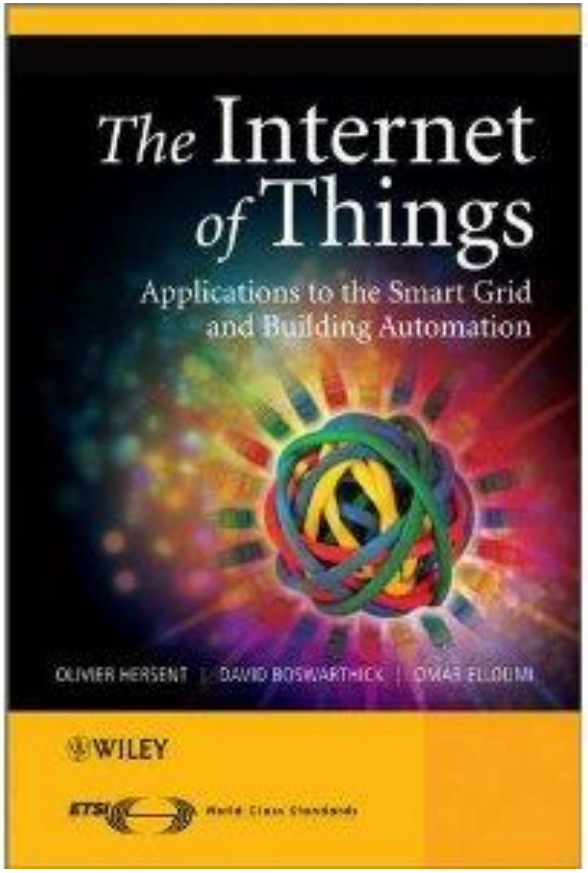
Plan A

Test and Selection Process

Implement

More on EV charging & SG…

- Book



On pre-order on Amazon UK January 2011

(LONWorks, KNX, 6lowPAN/RPL, Zwave, ZigBee 1.0 and **SEP2.0**, CAN, **IEC 15118**, MBUS/wMBUS, modBus, **Demand respons**e use cases …)