Introduction to ISO 15118
Vehicle-to-Grid Communication Interface

Begleitforschung „Schaufenster Elektromobilität“
Frankfurt, 2015-10-01
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Agenda

Part I

> Motivation for a high-level communication
> Philosophy of ISO 15118
> Architecture
> Use cases

Part II

> Information flows
> Sequence diagrams
> Data structures
> How to implement? (reference implementation, test cases)

Part III

> Privacy and security
MOTIVATION FOR A HIGH-LEVEL COMMUNICATION

Political and technical Regulations for E-Mobility

> European Union defined the 2020 climate and energy package, also known as "20-20-20" targets and Clean Vehicle Directive.
> "A 20% reduction in EU greenhouse gas emissions from 1990 levels;
> Raising the share of EU energy consumption produced from renewable resources to 20%;
> A 20% improvement in the EU's energy efficiency."
> Today (distribution) grid system configuration can be better operated with assistance of smart charging.
> Costs of grid enhancement exceed costs for “Smart Charging” clearly.
> Optimized usage of fluctuating renewable energy (photovoltaic, wind).
> Possibly development of new market(s) for selling flexibility of EV charging.
1. EU policy context of the next decade

Transport White Paper - March 2011
“Roadmap to a Single European Transport Area Towards a competitive and resource efficient transport system”

By 2030:
• Reduce transport GHG emissions by 20%
• Halve use of conventionally fuelled cars in urban centres
• Essentially free CO2 logistics in major urban centres

By 2050:
• Reduce transport emissions by 60%

2. Co-evolution Electricity and Transport system

• Together both industries have more potential for optimization than independent from each other
• Possibility to enable grid optimization taking into consideration as well user and grid needs
• Usage of existing ICT systems to do authentification
Towards sustainable mobility:
Introduction of alternative fuels will be indispensable

- Transport accounts for about 1/4 of GHG emissions in the EU:
  - 60% comes from passenger transport (especially cars)
  - 1/4 is urban transport
  - 1/5 is inter-continental transport
  - over half is medium-distance transport

Source: European Commission Transport White Paper 2011

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Electro mobility will play a major role in the future Smart Grid activities.

- Renewable power parks
- EV and EVSE
- DSO System services
- Smart Home
- Pooling (virtual power plants)
- Decentralized power generation and own consumption
- Data exchange on power demand and availability

Source: FTD, RWE
**Smart Charging combines security of energy supply and customer convenience.**

Effects of EVs and charging scenarios on the load curve

> Smart Charging limits the effects of additional loads on the distribution grid caused by EV’s
> Overload situations can be avoided up to a high market share of EV’s (~50%)
> Smart Charging offers the possibility to use the fluctuating generation of renewables
> No loss of convenience for the customer as the charging time is derived from customer preferences

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**Comparison of Grid Effects with different charging Power (uncontrolled Case)**

Assumptions:
> Suburban grid: 630 kVA per sub station
> Battery capacity: 16-35 kWh
> Penetration rate: 40% (EV/Household)
> rund 250 Haushalte (2000-8000 kWh/a)

Load curve with EVs (charging power 3.7 kW) – without control

Load curve with EVs (charging power 20 kW) – without control

Only short time overload
> How to react on this?

With target-oriented Management Grid Load can be reduced temporarily

With charge management a rate of 100% EV per household will be possible.


Wind Power Production at Ireland in % of current Demand as of Monday, 05. April 2010

Source: Eirgrid, Senan McGrath "The eCar Ireland Project", ESB ecars, 5.09.2011
PHILOSOPHY AND STRUCTURE OF ISO 15118

Philosophy of ISO 15118

> Use Control Pilot (CP) and Pulse Width Modulation (PWM) of IEC 61851-1 (similar to SAE J1772) for “safety”
> Support of several services
> Authentication “External Identification Means” (EIM) and “Plug ‘nd Charge” (PnC)
> Handling of digital certificates and electronic signatures
> Charging AC (Alternating Current) and DC (Direct Current)
> Respecting customer requirements
> Allows respecting of availability of capacity and power at (distribution) grid
> Allows respecting of price tables from energy (re)seller
> (re)negotiation of a charge profile with new parameters
> Value Added Services
> Respect security and privacy
> Provide enough bandwidth by using PLC technology based on HomePlug GreenPHY
> EV acts as a client, EVSE acts as a server
Smart electric cars, smart grids and charging stations will use a single data standard.

Advantages of the bidirectional communications protocol ISO 15118

<table>
<thead>
<tr>
<th>Simplicity</th>
<th>Grid friendliness</th>
<th>International importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Automatic authentication at charging points</td>
<td>&gt; Active load management through EV feedback</td>
<td>&gt; European and American acceptance of the deployment for AC charging</td>
</tr>
<tr>
<td>&gt; Automatic contract handling operation (new contract, change of contract)</td>
<td>&gt; Time-controlled charging possible</td>
<td>&gt; Worldwide acceptance for deployment for combined charging system (CCS) DC</td>
</tr>
<tr>
<td>&gt; Quick and easy foreign authentication (✉ Enabling of Europe-wide e-roaming)</td>
<td>&gt; Tariff-controlled charging possible</td>
<td>&gt; According to ACEA report of the OEM from 2017 integrated into all EVs</td>
</tr>
<tr>
<td>&gt; High security against data manipulation</td>
<td>&gt; Integration of renewable energy</td>
<td></td>
</tr>
</tbody>
</table>

Broad Spectrum of Participants shows high acceptance for expected Market – ISO/IEC JWG V2G CI 15118 in Figures

> Registered experts: 138
> Active countries: 13
> Passive ("reading") countries: 14
> Number of official comments to 15118 documents: ~ 6000
ISO Project Track (International Standard)

<table>
<thead>
<tr>
<th>Preliminary Stage</th>
<th>Proposal Stage</th>
<th>Preparatory Stage</th>
<th>Committee Stage</th>
<th>Enquiry Stage</th>
<th>Approval Stage</th>
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<tbody>
<tr>
<td>PWI</td>
<td>NP Ballot</td>
<td>Drafting</td>
<td>CD Ballot</td>
<td>Comments Resolution</td>
<td>DIS Ballot</td>
</tr>
</tbody>
</table>

Acceptance criteria:
- Approval simple majority of P-members
- 5 ISO members contribute in standard development

Acceptance criteria:
- 2/3 majority vote of P-members
- Consensus
- Not more than 1/4 negative votes of the total number counted

Default Time Frame
Extended Time Frame
Accelerated Time Frame

Optional
- Save negative DIS ballot
- PROOF

OSI-Layer - based standardization of Vehicle to grid communication – Analysis of options

<table>
<thead>
<tr>
<th>Layer</th>
<th>Data Communication Requirements</th>
<th>Technologies</th>
</tr>
</thead>
</table>
| 7 Application | • Payment & billing IDs and transactions  
| | • Anti theft, tamper detection  
| | • Pricing categories  
| | • Energy demand & response info (local limits, optional grid load levels, …)  
| | • Vehicle charge status & setup  
| | • Additional provider info (location, etc.)  
| | • Smart Energy Profile integration  | - Smart Meter Language (SML)  
| | | http://www.sym2l.org  
| | | - Common Information Model (CIM)  
| | | - Zigbee / HomePlug / Smart Energy Profile 2.0 (SEP 2.0)  
| | | - New standard  |
| 6 Presentation | | - SML transport layer  
| | | Internet Protocol Suite (TCP/IP & UDP) incl. security (TLS)  
| | | - New standard  |
| 5 Session | | - Wired/Wireless  
| | | Directly send data to customer  
| | | Use available industry standards  
| | | Seamlessly integrate into public charge spots and Smart Home infrastructure  
| | | Grounding circuit continuity monitoring and diagnostics  |
| 4 Transport | Reliable transmission  | - Secure & protect customer data  
| 3 Network | Secure & protect customer data  | - Directly send data to customer  
| 2 Data Link | Use available industry standards  | - SML transport layer  
| 1 Physical | - Seamlessly integrate into public charge spots and Smart Home infrastructure  
| | | - Grounding circuit continuity monitoring and diagnostics  |
ISO/IEC Road vehicles — Communication protocol between electric vehicle & grid - Document structure

Layer

1 Physical

ISO / IEC Communication Protocol between EV and grid
Part 3: Physical layer and data link layer requirements

2 Data Link

ISO / IEC Communication Protocol between EV and grid
Part 2: Technical protocol description and Open Systems Interconnections (OSI) layer requirements

3 Network

ISO / IEC Communication Protocol between EV and grid
Part 4 (NWIP): Network and application protocol conformance test

4 Transport

ISO / IEC Communication Protocol between EV and grid
Part 5 (NWIP): Physical layer and data link layer conformance test

5 Session

ISO / IEC Communication Protocol between EV and grid
Part 1: General information and use-case definition

6 Presentation

ISO / IEC Communication Protocol between EV and grid
Part 2: Technical protocol description and Open Systems Interconnections (OSI) layer requirements

7 Application

ISO / IEC Communication Protocol between EV and grid
Part 1: General information and use-case definition

Wireless Communication is developed within Project Team (PT) 7.
**Timeline for ISO 15118-4 and -5**

As of September 2015 (see official project status at ISO project portal)

**Structure of Norm ISO 15118 „Road vehicles — Vehicle to grid communication interface“**

> **Part 1:** General information and use-case definition (International Standard (IS) available since 04/2013)
> **Part 2:** Network and application protocol requirements (IS available since 04/2014)
> **Part 3:** Physical and data link layer requirements (IS available since 05/2015)
> **Part 4:** Network and application protocol conformance test (CD2 available since 02/2015)
> **Part 5:** Physical layer and data link layer conformance test (CD available since 08/2015)
> **Part 6:** General information and use-case definition for wireless communication (DIS available since 09/2015)
> **Part 7:** Network and application protocol requirements for wireless communication (CD under development)
> **Part 8:** Physical layer and data link layer requirements for wireless communication (CD under development)

**Availability:** Paper or PDF versions of DIS, FDIS, CDV and IS can be bought at ISO (www.iso.org) and IEC (www.iec.ch). CD versions are only distributed within Joint Working Group.
Role Model within ISO 15118

<table>
<thead>
<tr>
<th>Primary actors</th>
<th>Secondary actors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Vehicle</td>
<td>Supply Operator</td>
</tr>
<tr>
<td>Supply Equipment</td>
<td>Demand Operator</td>
</tr>
<tr>
<td>Communication Controller</td>
<td>Original Manufacturer</td>
</tr>
<tr>
<td>Electric Energy Meter</td>
<td>Distribution System Operator</td>
</tr>
<tr>
<td>Contactor</td>
<td>E-Mobility Operator</td>
</tr>
<tr>
<td>PWR</td>
<td>Meter Operator</td>
</tr>
<tr>
<td>HMI</td>
<td>Electricity Provider</td>
</tr>
</tbody>
</table>

Use Cases provided by ISO 15118

- **A** Start of charging process
- **B** Communication setup
- **C** Certificate Handling
- **D** Identification and Authorisation
- **E** Target Setting and Charge Scheduling
- **F** Charge controlling and Re-scheduling
- **G** Value Added Services
- **H** End of charging process

The Use Cases A to H are detailed into several Use Case Elements

Example: Authorization

- Identification Mode
- PnC
- EIM
- E.g. Credit Card
- Information
- Identification (0) Activation (1) Credentials (e.g. Contract ID) (2) Key (3) Authorization (4)

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## ISO 15118-1: Overview Use Case Elements (1/2)

<table>
<thead>
<tr>
<th>No.</th>
<th>Use case element name / grouping</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Begin of charging process with forced High Level Communication</td>
</tr>
<tr>
<td>A2</td>
<td>Begin of charging process with concurrent IEC 61851-1 and High Level Communication</td>
</tr>
<tr>
<td>B1</td>
<td>EVCC/SECC communication setup</td>
</tr>
<tr>
<td>C1</td>
<td>Certificate update</td>
</tr>
<tr>
<td>C2</td>
<td>Certificate installation</td>
</tr>
<tr>
<td>D1</td>
<td>Authorisation using Contract Certificates performed at the EVSE</td>
</tr>
<tr>
<td>D2</td>
<td>Authorisation using Contract Certificates performed with help of SA</td>
</tr>
<tr>
<td>D3</td>
<td>Authorisation at EVSE using external credentials performed at the EVSE</td>
</tr>
<tr>
<td>D4</td>
<td>Authorisation at EVSE using external credentials performed with help of SA</td>
</tr>
<tr>
<td>E1</td>
<td>AC charging with load levelling based on High Level Communication</td>
</tr>
<tr>
<td>E2</td>
<td>Optimized charging with scheduling to secondary actor</td>
</tr>
<tr>
<td>E3</td>
<td>Optimized charging with scheduling at EV</td>
</tr>
<tr>
<td>E4</td>
<td>DC charging with load levelling based on High Level Communication</td>
</tr>
<tr>
<td>E5</td>
<td>Resume to Authorised Charge Schedule</td>
</tr>
</tbody>
</table>

## ISO 15118-1: Overview Use Case Elements (2/2)

<table>
<thead>
<tr>
<th>No.</th>
<th>Use case element name / grouping</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0</td>
<td>Charging loop</td>
</tr>
<tr>
<td>F1</td>
<td>Charging loop with metering information exchange</td>
</tr>
<tr>
<td>F2</td>
<td>Charging loop with interrupt from the SECC</td>
</tr>
<tr>
<td>F3</td>
<td>Charging loop with interrupt from the EVCC or user</td>
</tr>
<tr>
<td>F4</td>
<td>Reactive power compensation</td>
</tr>
<tr>
<td>F5</td>
<td>Vehicle to grid support</td>
</tr>
<tr>
<td>G1</td>
<td>Value added services</td>
</tr>
<tr>
<td>G2</td>
<td>Charging details</td>
</tr>
<tr>
<td>H1</td>
<td>End of charging process</td>
</tr>
</tbody>
</table>
Data Communication controls Charging Session for better Integration of renewable Energy

**Example:**
Controlling charging session according to ISO 15118-2

1. **Contactor closed; send start meter reading**
2. **Send stop meter reading; please sign meter reading**
3. **Cable connected, CP/PWM ok, ask for service available**
4. **I want to charge with costs, my contract ID is "1234"**
5. **Lock connector; I will charge from 2 AM to 6 AM at 5 kW**
6. **Offer accepted: I will charge from 4 AM to 6 AM at 11 kW**
7. **I want to stop charging session; open contactor**
8. **Signing drawn energy, unlock cable, end of communication**

ISO 15118 uses $P_{\text{max}}$ and Tariff Tables for easy Integration of EVs into Power Grid and Power Production

**Grid and Power Production Tariff Table**

<table>
<thead>
<tr>
<th>TariffStart (Seconds from now)</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7,200</td>
<td>14,400</td>
<td>21,600</td>
<td></td>
</tr>
<tr>
<td>TariffMax (Watt)</td>
<td>22,170</td>
<td>11,085</td>
<td>6,928</td>
<td></td>
</tr>
<tr>
<td>EPrice (relative, in %)</td>
<td>100%</td>
<td>70%</td>
<td>80%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**TariffTableType**

- **Currency**: REL
- **Tariff**: T1
- **EPriceUnit**: 1 (one percent)
- **EPriceMultiplier**: 1

**Source:** According to Committee Draft ISO 15118-2
Load Management according to ISO 15118 with a Smart fortwo ed 3 connected to an RWE Charge Spot

Charging power was restricted by cable, installation, feed-in and grid transmission capacity to max. 22 kW.

Electricity reseller offered a special price for this charging session at 50 % off, but between 10:30 and 11:00 AM normal price (100 %) had to be paid. During this period EV stopped charging.