AFIR and OCPP

v1.0 January 2024

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1. Introduction

The AFIR [1] regulation by the European Commission aims to promote the expansion of alternative fuels infrastructure, including electricity and hydrogen, throughout the EU. The regulation has several objectives, including ensuring uniform technical standards, promoting interoperability, enhancing user-friendliness, and transparency. AFIR comes into force as of April 13th, 2024.

Under the regulation, EU Member States are required to provide publicly accessible charging stations for electric vehicles. A certain minimum available charging power is required, related to the number of electric vehicles registered in the respective countries. The regulation also sets distance-based targets for the availability of charging stations along the Trans-European Transport Network (TEN-T), including requirements for light-duty and heavy-duty vehicles.

To ensure compatibility and standardization, the regulation defines technical specifications for electric vehicle recharging points, covering aspects such as socket outlets, vehicle connectors, plug and socket types and sizes, and communication protocols. Recharging points must be compatible with common connectors and use intelligent metering systems to measure and record electricity supply.

User-friendliness and transparency are emphasized in the regulation. Charging stations must provide clear information on pricing, availability, and location, and allow ad-hoc access without a pre-existing contract. Standard payment methods like credit cards or mobile apps should be supported, and discrimination between users or service providers is prohibited. Smart charging is also encouraged to optimize the use of renewable energy sources and encourage recharging at times of low general electricity demand and low energy prices, with benefits for the electricity system and for the end user.

Although AFIR does not yet mention the standard communication protocol that shall be used between charging station and management system, this paper discusses AFIR with respect to charging station implementations and charging station management with OCPP, because OCPP is the de facto standard at the moment. This paper focusses on the aspects of AFIR where OCPP plays a part: it aims to help the EV charging industry adhere to the AFIR requirements.

Whereas AFIR focuses on public charging stations, the Renewable Energy Directive (RED) [2] explicitly targets non-publicly accessible charging stations as well. The reason being that electric vehicles that are parked repeatedly for long periods of time at residential parking places or employee parking, are highly relevant to energy system integration.

The proposed new article 20a in RED adds that new and replaced non-publicy accessible normal power charging stations shall support smart charging capabilities, interface with smart metering systems and have bidirectional charging functionality in accordance with the requirements of article 15 of AFIR. This article in AFIR states that each member state shall assess every three yeears the potential contribution of bidirectional recharging to

reducing user and system costs and increasing the renewable electricity share in the electricity system.

RED does not add requirements to charging stations that are not yet present in AFIR.

2. AFIR terminology mapping

The terminology used for charging stations in the regulation differs from what is used in OCPP. It also differs from the terminology in NEVI [3], which is a standard in the United States of America that is to a certain extent comparable to AFIR as far as electro-mobility is concerned.

The following table provides a translation from AFIR terminology to NEVI and OCPP terminology.

AFIR	NEVI	OCPP 2.0.1
Recharging point	Charge port	EVSE
Recharging station	EVSE	Charging station
Recharging pool	Charging station	—
Smart recharging	—	Smart charging

This paper uses the OCPP terminology for charging infrastructure, because it is aimed at an OCPP-aware audience.

3. AFIR articles

AFIR consists of 26 articles. Article 1 describes the subject matter. Article 2 contains a list of definitions. Then we get three articles in AFIR that are aimed specifically at the charging infrastructure.

Articles 3 and 4 set targets for the amount of charging infrastructure for light-duty, resp. heavy-duty electric vehicles. Article 5 sets requirements for the charging infrastructure. The chapter Fulfilling AFIR with OCPP discusses how a charging infrastructure based on OCPP can fulfill these requirements.

Articles 6 to 13 are about other forms of alternative fuel, like hydrogen and liquified methane, and about shore-side electricity in maritime ports and for stationary aircraft. These are not in scope of this paper and neither are the articles 14 to 19, which deal with national policy frameworks and reporting.

Article 20 is relevant for charging network operators, but not for OCPP. It lists the required static and dynamic properties of charging stations that shall be published to the national access point of the country.

Article 21 relates to charging infrastructure in the sense that it describes which technical specifications to use. The remaining articles, 22 to 26, are of a procedural nature and not relevant for this paper.

The following paragraphs dive more into the AFIR articles that are relevant to charging infrastructure.

Article 3 - Targets for recharging infrastructure dedicated to light-duty electric vehicles

This article stipulates that charging locations must become available along the major transport routes for light-duty electric vehicles, i.e. passenger cars and vans. The following is a much simplified summary of the article.

Along the TEN-T [4] core road network charging locations must made available every 60 km.

- By the end of 2025 each of these charging locations must provide at least 400 kW power output in total and include at least one EVSE of 150 kW or more.
- By the end of 2027 these location must provide at least 600 kW power output and include at least two EVSE of 150 kW or more.

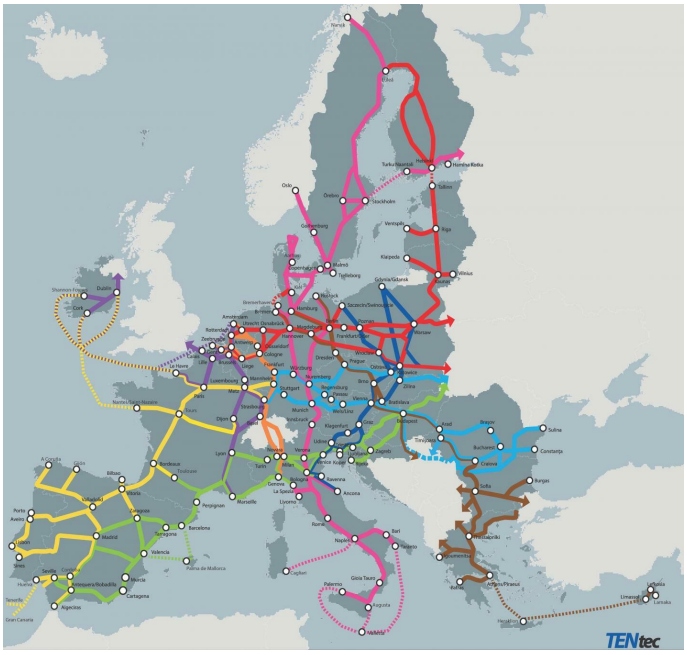

Figure 1. Map of the TEN-T network

(Image by Directorate-General for Mobility and Transport, European Commission) [5]

Article 4 - Targets for recharging infrastructure dedicated to heavy-duty electric vehicles

This article stipulates that charging locations must become available along the major transport routes for heavy-duty electric vehicles, i.e. trucks and buses. The following is a much simplified summary of the article.

Along the TEN-T core road network charging locations must made available every 60 km.

- By the end of 2027 half of the length of the TEN-T network must offer publicly accessible charging locations with at least 2800 kW of power output and include at least two EVSEs of at least 350 kW.
- By the end of 2030 this must have been achieved for the full length the TEN-T network.

Article 5 - Recharging infrastructure

Article 5 sets requirements for the charging infrastructure. Most of the paragraphs in this article are related to how the charging station operator manages the stations with respect to payment and pricing, and the capability to support smart charging. This means that article 5 is the most interesting, as far as OCPP is involved.

Payment terminals

All publicly accessible charging stations must support ad hoc payment with a card reader or contactless reader

of payment cards. Only charging stations with EVSEs with a power output below 50 kW are allowed to rely on ad hoc payment via a mobile app or website, for example via a QR code. It is allowed to use a single payment terminal for all charging stations at a charging location.

Automatic authentication

Charging stations that support automatic authentication, i.e. Plug & Charge or AutoCharge, must also provide the user the option for ad hoc or contract-based payment. The regulation states "Operators of recharging points shall clearly show that option to end users and offer it to them in a convenient manner at each publicly accessible recharging point operated by them, at which they make available automatic authentication." It does not literally say that that a user needs to consent with automatic authentication via a choice on the display first, but that may be the ultimate consequence.

Pricing

"Operators of publicly accessible charging points shall not discriminate, through the prices charged, between end users and mobility service providers or between different mobility service providers."
The ad hoc price, for example, must be the same for every end user at the same location and time. This non-discrmination principle, however, does not imply that the consumer ad hoc price must be the same as the wholesale price towards the mobility service providers.

The ad hoc price at charging stations with EVSEs with a power output equal to or more than 50 kW shall be based on the price per kWh for energy delivered. Additionally, an occupancy fee (idle fee) as a price per minute can be charged to discourage long occupancy of the charging station.

The kWh price and optional occupancy fee must be shown to the user. For EVSEs with a power output equal to or more than 50 kW this must be shown at a display of the charging station. For EVSEs with less power this information must be available, but not necessarily on a display.

There is even a specific order specified:

1. price per kWh
2. price per minute
3. price per session
4. any other price components

Interestingly, there is no requirement in AFIR to show a real-time running cost on the display, as is the case in the California CTEP requirements.

Mobility service providers must provide their price information prior to starting a charging session, through a mobile app or website ("through freely available, widely supported electronic means"). There can be no extra charges for cross-border e-roaming.

Connectivity and smart charging

All publicly available charging stations shall be digitally-connected charging stations, as of October 14th, 2024. Furthermore every public charging station that is newly installed after April 14th 2024, or renovated after October 14th 2024, shall be capable of smart charging. No details are given on how smart charging is performed

or which roles are involved.

The remainder of the paragraphs deal with requirements that are not affected by OCPP, such as compliance monitoring and adequate signposting.

Article 20 - Data provisions

Paragraph 2 of Article 20 describes the static and dynamic data about charging stations that an operator must provide. Paragraph 6 of this article, however, allows the Commission to extend paragraph 2 with additional data types and technical requirements at a later point in time.

The following list of data types from paragraph 2 can therefore not be regarded as final.

Operators shall provide **static** data about publicly accessible charging stations with

1. geographic location,
2. number of connectors,
3. number of parking spaces for people with disabilities,
4. contact information of the owner and operator ,
5. opening hours,
6. ID codes, at least of the charging station operator,
7. type of connector,
8. type of current (AC/DC),
9. maximum power output (kW) of the charging station,
10. maximum power output (kW) of the EVSE,
11. vehicle type compatibility;

Operators shall provide **dynamic** data about publicly accessible charging stations with

1. operational status (operational/out of order),
2. availability (in use/not in use),
3. ad hoc price,
4. electricity supplied is 100% renewable (yes/no).

The operator shall provide APIs to provide access to this data and submit it to the national access points.

Article 21 - Common technical specifications

Article 21 refers to Annex II for the technical specifications that shall be used, and mentions that the European Commission may request European standardisation organisations to draft new standards for areas for which no technical specification has been adopted by the Commission.

Technical specifications for many areas are still missing in Annex II. For the charging infrastructure only the technical specifications for connectors (connector types) are present:

- AC EVSEs shall use the Type 2 connector.
- DC EVSEs shall use the CCS2 connector.
- AC connectors for the L-category of electric vehicles, e.g. scooters and three-wheelers, shall use the Type 3A connector (also known as the single phase Scame connector) for Mode 3 charging, or a regular household socket for Mode 1 or 2 charging.

4. Fulfilling AFIR with OCPP

The following paragraphs explain how OCPP can be used to fullfil the AFIR requirements.

4.1. Ad hoc payment

The requirement to support ad hoc payment means that charging stations must support an integrated payment terminal, or be connected to an outdoor payment terminal that handles the ad hoc payment for the entire charging location.

Integrated payment terminals

The payment terminal provides the authorization to charge when payment is approved. In case of an integrated payment terminal, this authorization to charge is passed internally to the charging station controller. Since there are many different payment terminals with different digital interfaces, there is no standard solution described in OCPP about the interfacing of a charging station towards the integrated payment terminal.

In OCPP 1.6 the message that carries the authorization of the payment terminal with any associated data that is needed for a receipt (authorization reference, card last 4 digits, etc.), is a custom message. A `DataTransfer` message is used to transfer this data. The exact implementation differs per manufacturer. The same applies to the custom message via which the charging station sends the "capture status" from the payment terminal to CSMS to tell whether the payment has been settled by the payment service provider.

In OCPP 2.0.1 this data can be sent as part of the regular `AuthorizeRequest` in which the associated data can be sent in the *additionalInfo* fields of this message. Although it is a standard message, it is not defined how the *additionalInfo* fields be used. As a result there can still be differences among implementations from charging station manufacturers. The message that reports to CSMS whether the payment has succeeded, is still a custom message in OCPP 2.0.1.

In OCPP 2.1 (to be released in 2024) this process will become fully standardized with the aim to provide a common approach to the handling of payment terminal information within OCPP. There will be no need for any custom messages, thus ensuring full interoperability.

Outdoor payment terminal

An outdoor payment terminal for a charging location has no direct connection with the charging stations. Instead, this authorization is passed to the charging station managment system (CSMS) together with the identifier of the charging station at which the user plans to start charging. CSMS will then request this charging station to start a charging session for the user. In OCPP 1.6 this done via the `RemoteStartTransaction` message. In OCPP 2.0.1 this is called the `RequestStartTransaction` message.

When the user stops the charging session, CSMS notifies the outdoor payment terminal of this, which will in turn settle the payment with the payment service provider. The outdoor payment terminal will notify CSMS when it has settled the payment.

The interface between payment terminal and CSMS is not in the realm of OCPP. There is no agreed standard for this interface in the payment terminal industry, but it could be implemented by using the standardized OCPI protocol that is used for communication between mobility service provides and charging station operators, should the payment industry be open to such an approach.

4.2. Pricing

Display

The kWh price and optional occupancy fee must be shown to the user. For EVSEs with a power output equal to or more than 50 kW this must be shown at a display of the charging station. OCPP 2.0.1 offers the `SetDisplayMessage` command for this purpose. Similar functionality can be implemented on OCPP 1.6 by using a custom configuration variable, or via a custom `DataTransfer` message.

Cost calculation

OCPP 1.6 and OCPP 2.0.1 assume that the cost of a charging session is calculated in the backend, CSMS. The payment terminal needs to know the final amount in order to settle the payment. OCPP 1.6 would require a custom message to send this, but OCPP 2.0.1 can return the total cost in the so-called `TransactionEvent` message at the end of the transaction.

In practice, however, implementers often choose to calculate the cost locally on the charging station because ad hoc pricing is usually fairly simple, consisting of a kWh price and perhaps a start fee. This data is then configured in the charging station as a simple price per kWh, which is used to calculate the cost locally. For OCPP 1.6 this has the advantage that no custom message to get the cost from CSMS is needed.

CTEP customization

In 2021 Open Charge Alliance published a paper [6] describing customizations for OCPP 1.6 and OCPP 2.0.1 that implement new features to support the price display and local cost calculation on the charging station, as is required by the California Type Evaluation Program (CTEP) [7]. These customizations can also be used to implement the AFIR requirements to display price and support ad hoc payment.

In a nutshell, the CTEP customization for OCPP 1.6 has a configuration variable that holds the description for the ad hoc charging price that is displayed on-screen. When the transaction starts CSMS sends a custom message (DataTransfer) that holds the charging price per kWh or unit of time, and optionally an idle fee. Based on this information the charging station can perform a local cost calculation to show a real-time running cost on the display. CSMS is still in the lead for calculating transaction cost. After every meter value that a charging station sends to CSMS, it will receive the official cost as calculated by CSMS in a DataTransfer message, such that the charging station can keep its local cost calculation synchronized with CSMS.

For OCPP 2.0.1 a CTEP implementation requires less customization. The ad hoc charging price can be shown using the standard SetDisplayMessage function of OCPP 2.0.1. When the transaction starts CSMS sends a `CostUpdated` message, that contains a custom field `chargingPrice` that holds the charging price per kWh or

unit of time, and optionally an idle fee. Again, CSMS is in the lead for the cost calculation, and upon every meter value that charging station sends to CSMS, it will receive the official cost as calculated by CSMS in the `CostUpdated` message, such that charging station can keep its local cost calculation synchronized with CSMS.

Cost calculation in OCPP 2.1

OCPP 2.1 has been extended to explicitly allow for local cost calculation on the charging station. OCPP 2.1 supports tariff plans that can be uploaded to the charging station, and that support complex tariff plans for time-of-day prices or smart charging. When cost is calculated on the charging station, real-time display of cost while charging is possible. This is, however, not a feature that AFIR requires.

An OCPP 2.1 tariff can describe the cost of a charging session using the following dimensions:

- Energy (`kWh`)
- Charging time (`ChargeHours`)
- Flat fee (`Flat`)
- Idle time (`IdleHours`)

This maps perfectly on the allowed price components mentioned in Article 5 - Recharging infrastructure.

4.3. Smart charging

AFIR requires that charging stations support smart charging. Smart charging capability has already been natively supported as of OCPP 1.6.

Bidirectional charging

Bidirectional charging capability is not mandated by AFIR, but there are some references to it.

In Article 14 "National policy frameworks" member states are requested to report measures to ensure that deployment and operation of charging stations, including the geographical distribution of bidirectional charging stations, contribute to the flexibility of the energy system. In Article 15 "National Reporting" member states are required to assess every three years the potential contribution of bidirectional charging to reducing user and system costs and increasing the renewable electricity share in the electricity system.

OCPP 2.1 will support bidirectional charging, but a limited form of bidirectional charging is already possible with customized versions of OCPP 1.6 and 2.0.1.

5. Summary

The following table summarizes the support in different OCPP versions for AFIR requirements regarding ad hoc payment and pricing, and smart charging.

OCPP 1.6 offers no native support for ad hoc payments, because it has no standard features to deal with payment terminals, displays or cost.

OCPP 2.0.1 adds features to control a display on the charging station and to get session cost from CSMS. It still assumes, though, that CSMS is in charge of cost calculation. Local cost calculation can be achieved with the CTEP

customization for OCPP 2.0.1. After OCPP 2.1 is released, OCA will publish a customization for OCPP 2.0.1 to enable it to support the same ad hoc payment flow as in OCPP 2.1.

OCPP 2.1 standardizes the data exchange with CSMS that is needed to support payment terminals for ad hoc payments, adds tariff plans and the capability to do cost calculation locally on the charging station, and adds full support for bidirectional charging.

Smart charging has always been a part of OCPP as of version 1.6.

AFIR requirement	**1.6**	**2.0.1**	**2.1**
Ad hoc payment	customization	OCA customization	native support
Pricing display	OCA customization	native support	native support
Cost calculation	OCA customization	centrally: native support locally: OCA customization	native support
Smart charging	native support	native support	native support
Bidirectional charging	not supported	not supported	native support

[1] Alternative Fuels Infrastructure Regulation, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1804
[2] Revised Renewable Energy Directive, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413
[3] National Electric Vehicle Infrastructure Standards and Requirements, https://www.federalregister.gov/documents/2023/02/28/2023-03500/national-electric-vehicle-infrastructure-standards-and-requirements
[4] Trans-European Transport Network
[5] Image by Directorate-General for Mobility and Transport, European Commission, https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=121232873
[6] OCPP & California Pricing Requirements, https://www.openchargealliance.org/uploads/files/ocpp_and_dms_evse_regulation-v2.0.pdf
[7] CTEP, https://www.cdfa.ca.gov/dms/programs/ctep/ctep.html