EVRoaming Foundation
Realising cross-border charging

White paper

Issues and solutions for better exchange and understanding of EV charging tariffs

Version: part 1 CPO-MSP v 1_0
May 2023

Introduction

Does an EV driver know and understand what he/she will pay for the charge session? Often the answer is: "No". EV driver tariffs are complex which can be caused by many reasons: because of complex tariffs earlier in the chain or by demands in tenders. Besides that the way tariffs are dealt with by different parties in the chain and how they are exchanged is not always efficient. As a result of this complex set ups and in-efficient exchange, EV drivers often can't access the actual (total) tariff before the start of their charging session. If we don't act and improve now, it will only get worse in the coming years.

This document describes the situation, the issues and proposes solutions on how to deal with tariffs between CPO and MSP as well as towards EV drivers.
This document is focusing on the business processes and not directly on protocols.

However it is important that protocols support the recommendations. It is verified that at least OCPI v2.2.1 can process the recommendations.

This White Paper contains 3 parts:

1. The relation between CPO and MSP and how they should deal with tariffs. This includes also a technical annex on how to deal with the recommendations from a technical perspective. (This is the current released part of the white paper)
2. The relation with the EV drivers and how parties should approach them with their tariffs. This is partially a result of the situation between CPO and MSP, but contains also information about signage, and expectations from EV drivers
3. What governments and other organizations should take into account concerning charging tariffs in their tenders and requests for proposals.

Part 2 and 3 will be available in Q3 2023.

Main used terms explained

- Tariff: the amount that needs to be paid per component. E.g.: 45 cent per kWh or 2 cent per minute.
- Tariff component: the type of tariff e.g. kWh, minute
- Tariff set: a group of tariffs that are used for a single charge action
- Tariff ID: a code to identify a certain tariff or tariff set
- Costs: the total amount that needs to be paid for the total session, including all tariffs x used amount.

Goal

There are two goals for this document:

1. Create better understandable, transparent and traceable calculated tariffs for EV drivers
2. Create more efficient, correct and accurate tariff data exchange between market parties (i.e. between CPO's and MSP's)

Target group

This document is important for everyone that has to deal with tariffs in the EV charging market:

- Governments who set regulations
- Everyone that set out tenders for charging infrastructure and include requirements for tariffs
- Charge Point Operators and Mobility Service Providers

Basic regulations on tariffs

A consumer must:

- Be able to know the tariff(s) for charging before they start the charge session
- Understand the tariff and how the costs for the charge action are calculated
- Be able to see the progress and cost for the charge action during a session split per used component.
- Receive an overview of the cost immediately after the charge session, including all components, so that he/she can verify this with the tariffs before the charge action.

Problems in the current situation

There are currently two main problems, regarding charging tariffs:

1. The charging tariff for EV drivers is often not known or difficult to find, unclear, not easy to understand, and hard or impossible to use for verification of the transaction and invoice after the charging activity.

2. Tariff exchange between Charge Point Operators (CPO) and Mobility Service Providers (MSP) is:
    a. Not always communicated by a proper technical connection and protocol
    b. Inefficient and hard to manage
    c. Complex
    d. Difficult for keeping track of obligated historical data

If the MSP receives complex tariff sets from the CPO , this often results in a complex tariff structure for the EV driver OR in a structure that doesn't correspond to the CPO-MSP tariff structure. This backfires directly EV drivers, not capable of receiving correct price information prior to the charging session
By the CPO-MSP tariff setting the CPO often wants to manage charging behavior. However if the MSP does create the EV driver tariffs in the same way, it will not have the intended effect and impact.

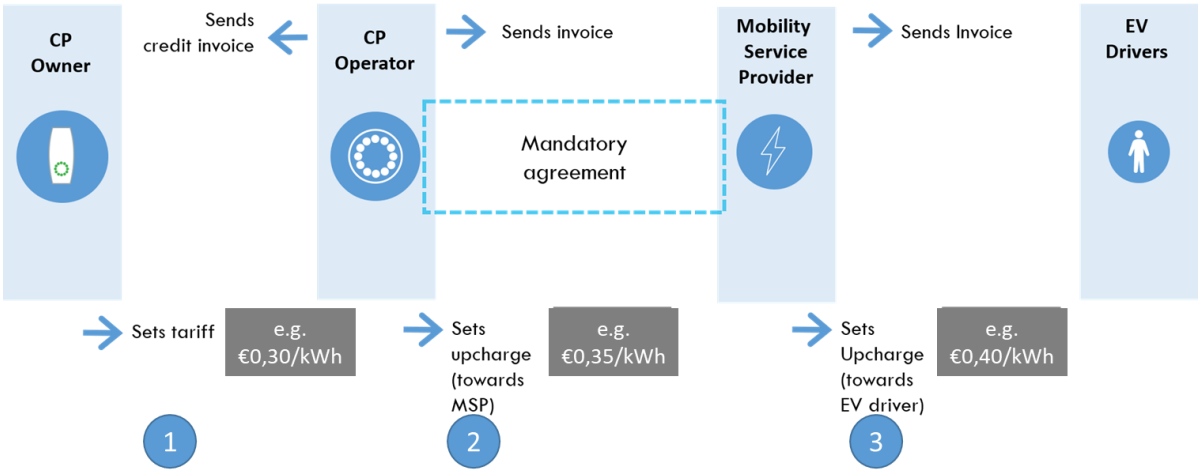
Complicated tariffs are often simple tariffs explained in complicated ways.
The EV charging market is growing rapidly and all kinds of new developments are coming e.g. smart charging, dynamic energy tariffs, etc. These developments will raise the problems, if we don't agree on solutions now.

This document describes the above problems and proposes solutions. The first part describes how tariffs are defined. The second part describes the situation between CPO and MSP and the third part describes the situation for the EV driver. Each part ends with conclusions and proposed measurements.

How are tariffs defined and set?

(The mentioned tariffs in this document can be in any currency. For clarity € is chosen in the examples)

The following overviews show the "tariff value chain" in a basic simplified form:



(The "mandatory agreement" between CPO and MSP is referring to the roaming agreement. An agreement between CP owner and CPO and the MSP and EV driver should also be in place.)

This overview shows that there are at least 3 steps where the tariff is set and modified.
The EV driver tariff is the result of many different tariff components and can contain:

- Start or transaction fee
- Minute fee during charging
- kWh fee
- Roaming service fee
- Parking fee
- Idle time fee (when car is parked at a charger, but not charging)
- Service fee CPO (upcharge CPO-MSP)
- Service fee MSP (upcharge MSP-EV driver)
- Priority fee

The CPO can also offer Ad Hoc access to their public accessible charge stations without the need of using a MSP (this is an obligation in Europe). The transaction is paid with a direct payment system connected to the CPO. The CPO offers an Ad Hoc Charging tariff for the EV driver, which can have the same tariff components as mentioned above, although in most situations it is limited to one or two components.

Part 1: The relation between CPO and MSP

CPO – MSP tariff exchange

CPOs are invoicing the charge sessions on their charge stations to the MSP. This can contain many (sometimes up to ten) different components from kWh to minutes, start rates, etc. There are a huge amount of CPOs and MSPs active in the world. In all regions they are connected to each other and exchange the tariffs from CPO to MSP; this is the sales price for the CPO and the cost price for the MSP.

Tariffs are not always communicated by a proper technical connection and protocol
Tariff exchange sometimes doesn't happen at all. Every roaming protocol supports sharing tariffs, but there are still CPOs that either don't publish their tariffs, or publish them in a non-standard way (a page on their website, a custom API, ...). The roaming hubs have a lot of technical problems with tariffs too.

Recommendation:
Always use a good technical connection and protocol to your partners for publishing and sharing tariffs. If you're using a roaming hub ensure this hub can handle the tariffs in the right way.

In Annex 1 of this document we explain how you can deal with the main issues and recommendations on protocol level, including some examples. It is explained with OCPI v2.2.1.

Inefficiency because of large number of tariffs
CPOs set per charge point a price for a charging session. This is done using a "Tariff ID" and a "Tariff" which can contain many different components. All these Tariffs are exchanged with their connected MSPs. Currently, this results in up to 130.000 different Tariffs (Tariff ID + Tariff information) for a single MSP. As each CPO is sharing their tariffs with their MSPs, many millions of tariffs are exchanged, and none of the market parties are able to check and differentiate the valid tariffs from the non-valid tariffs.
The higher the number of tariffs, the bigger the risk that something goes wrong. Besides that it is not efficient.

- The biggest risk is that something goes wrong with synchronising the tariffs between CPO and MSP
- If there are issues with tariffs, it is easier when there are no redundant tariffs.

A large part of these tariff sets contain exactly the same tariffs, but only have a different Tariff ID.

There are companies that use a different tariff ID per charge point or charge station, even when the same tariff is applied to another charge point.

- This can easily be improved by following internal procedures in companies (often CPOs) not to use different Tariff IDs for the same tariffs.

This is making tariff exchange needlessly inefficient because of the huge amount of redundant tariffs.

Most CPOs use 2 types of tariffs:

- Fixed tariff types, which are not specific for a specific location or customer. E.g. [ID: EURS050E035 - €0,50 start rate and €0,35/kWh] and [ID: EURS050E040 - €0,50 start rate and €0,40/kWh]. These tariffs cover most of their cases and can contain several components, although often limited to three.
- Custom tariff types, which are created for a specific location or customer and can contain many different components and variations. E.g. [ID: V21E073T0275 - €0,73/kWh and €0.275 after 90 minutes]

Recommendation:
use Fixed tariff sets as much as possible and re-use them; don't use a separate tariff set with separate tariff ID for each charge point or station.

Issue with changing tariffs/variable tariffs at a station before charging
The market is moving more and more to flexible energy tariffs, different tariffs depend on certain delivered or max power, different tariffs as a result of smart charging, or different tariffs because of other events e.g. how busy it is at a certain charge location (location with several charge stations).

There are many reasons to do this e.g.:

- Flexible energy contract by the CPO can result in different prices for the MSP
- By different tariffs, EV drivers can be encouraged to charge at different times (i.e. used to try to change charging behavior)
- Different tariffs can be the result of different (max) delivered power at the station
- Etc.

Variable tariffs are used in the following situations:

- Peak- vs non peak tariff sets: based on fixed parameters (i.e. time between 4pm and 8pm) a peak price would be given. Currently there are two ways how companies deal with the situation when a session is part of a peak and off-peak time slot:
    - Sometimes the tariff is used during the whole session that was applicable when the charge session started.
    - Sometimes the tariff is changing during the session when peak/off-peak tariff is starting. In these situations, this must be clear to the EV driver before charging.
    - Sometimes an idle fee is added to a charging session, for example when the EV reached a certain % SoC. The impact of this on the total session costs can only be known when this situation occurs.
- Dynamic energy tariff sets based on actual energy costs (also called "spot pricing"): This is used by the CPO or charge station owner in case of flexible energy contracts with day-ahead prices. In these situations the actual tariff can be different over time with a granularity in time of 15 minutes up to 24 hours. The dynamic energy prices can also be based on average energy cost. However CPOs often already know their price in advance (or are able to retrieve a price forecast of their retailer in advance). Often they don't communicate revised prices to MSPs in time.
- Dynamic parameter tariff sets based on CPO specific pricing policies: These are situations where the CPO changes the price because of a certain event. Currently there is no agreed time window when these tariffs are known, as a result it can be right before the start of a charging session. For example, in the case of:
    - Utilization dependent pricing: based on the forecasted charging demand at X time, CPO increases or decreases tariff
    - Prioritized pricing: based on actual 'reservations'

Although different tariffs at different moments are not making it more clear for as well the MSP as the EV driver, the current trend is not easy to change.

There are more and more situations that MSPs and EV drivers have to deal with a changing tariff right before charging. This is not desirable for both MSP and EV drivers.

The most flexible and unknown tariff is caused by flexible energy contracts that the CPO has with its utility. This tariff is known at least 12 hours before it is applicable (so called "Day Ahead tariffs) and defined by the utility company based on among others expected demand and response of energy. Other tariffs might be based on this tariff.

There are also situations where the CPO-MSP tariffs and EV driver tariffs are based on actual changing situations e.g. the usage of chargers. In these situations the tariffs are known far before it happens. The only thing that is unknown is when this situation occurs.

Recommendations:

1. *The CPO must set the tariff changes for the MSP at latest 10 hours before it is applicable, so that the MSP has enough time to inform the EV driver, which should be at least 8 hours before it is applicable. This includes all changes on the already known parameters by the MSP (time of use €/kWh, idle fee €/time, etc).*

2. *The CPO should inform the MSP about any other tariff mechanism which occurs based on real time insights (e.g dynamic fees based on utilisation or idle fees). The CPO has a certain freedom to apply for the following mechanisms, but is obliged to communicate this transparently to MSP and EV drivers: in time and in line with the previous recommendation.*

3. *A CPO must not use energy spot pricing (= pricing based on actual energy cost at a certain moment) to MSPs and MSPs should not use energy spot pricing to EV drivers for public charging, except when there is an explicit agreement between CPO, MSP and EV driver. The goal of spot pricing is to push energy usage that is not time sensitive to off-peak hours, and implement load balancing on an international level. This works for utility contracts, under the assumption that smart appliances and charging stations can receive the spot pricing via an API, and plan their energy usage without human intervention. We don't believe it works for public charging. People will not change their travel plans based on the spot prices of the day. The amount of tariff IDs will also explode as all tariffs need to be created and stored for auditing and historical reasons.*
   For private charging the situation can be different.

4. *Dynamic tariffs can be used if:*
   a. *It doesn't introduce too much complexity.*
   b. *It can be represented using the existing tariff restrictions.*
   c. *It is still relatively straightforward to communicate the kWh consumption rate for each time window of the day to the user.*
   d. *Users can still estimate the cost of their session before starting the charge*
   e. *It could easily be extended to include validity periods via start_date_time/end_date_time.*
   f. *A CPO transparently communicates in an electronic way via protocols to the MSPs, the parameters based on which dynamic tariff mechanisms will be activated.*
   g. *CPO and MSP have a contract in place to enable a MSP to activate dynamic models (i.e. opt-in for spot prices, opt-in for utilisation based fees)*

   Example: peak and off-peak hours and tariffs (i.e. dynamic tariffs) that are known and can be sent by the CPO to the MSP at least 10 hours before it is applicable. See also recommendation 1.

5. *Every CPO is obliged to actively push a warning/notification to the connected market parties to make them aware of:*
   a. *price update*
   b. *time and day of enforcement*
   c. *affected price sets or - components (or IDs)*

Note:
Tariffs changing based on actual conditions can be hard or impossible to share with partners as current protocols do not support this.

Issue with changing tariffs but keeping same Tariff ID

A Tariff for a certain charge activity is not only used to know the tariff before charging, but also to verify the total costs after the charge session, if this is in line with the 'agreed' tariff before.

This means that a certain tariff ID should have the same tariff for a long period, for companies to be able to verify invoices. Currently there are CPOs that keep the same tariff ID, but change the tariff. This is creating all kinds of technical challenges: on the MSP side to keep historical data, and on the CPO side to prove a certain used tariff in the past.

It must always be clear for the MSP which tariff is valid at a certain moment.

<u>Recommendation:</u>
A Tariff (tariff ID + tariff) must not be changed once it has been published.

Issue with many tariff components in CPO-MSP tariffs

CPOs often create complex tariff sets, with up to 8 different tariff components (e.g. start fee, kWh fee, minute fee, etc.). All these components can get a certain value and become part of the charging costs. MSPs often base their EV driver tariffs on the tariffs and cost that they get billed by the CPO with a margin on it. When CPOs use many different tariff components, the MSP either:

- Forward this directly to their EV drivers which results in complex, hard or impossible to understand EV driver tariffs,
- Forward these complex tariffs to their EV drivers after simplifying and reducing them. The result will be that there is no direct relation anymore in the tariffs set by the CPO and the EV driver tariffs. If this is done by the CPO to change charging behavior this effect is totally gone.

Recommendation:

1. *A charging tariff should not contain more than 3 different components. Not between CPO and MSP and not for EV drivers.*
2. *The setup of tariffs by CPO to tMSP should be used in the same way for MSP - EV driver tariffs*

Protocol conformity

If tariffs change at a charge station, be sure a protocol is used that supports it to inform the other party beforehand. If you want to change a tariff at a charge station frequently (e.g. more than once a day) make sure you use a protocol that supports announcing the change before it is actually changing. (e.g. OCPI 2.2.1.)

ANNEX 1
Proposed standardised way how CPOs and MSPs can deal with tariffs in a technical way – based on Tariff module from OCPI v.2.2.1

Proposal 1: use restrictions only when the price changes

OCPI gives us many ways to represent the same price, let's take an example:

Let's say we want charging costs to be 0.50E/kWh.

We can express this by simply defining a single segment containing a single energy component:

```
{
 "id": "my-tariff",
 "segments": [{
    "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}]
 }]
}
```

But we can also express it by defining 7 segments with dayOfWeek restriction each containing a single energy component

```
{
 "id": "my-tariff",
 "segments": [
  {
    "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}],
    "restrictions": {"day_of_week": [ "MONDAY" ]}
  },
  ...,
  {
    "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}],
    "restrictions": {"day_of_week": [ "SUNDAY" ]}
  }
 ]
}
```

Or we can do multiple segments using the start_time / end_time restrictions

```
{
 "id": "my-tariff",
 "segments": [
  {
    "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}],
    "restrictions": {"start_time": "00:00", "end_time": "12:00"}
  },
  {
    "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}],
    "restrictions": {"start_time": "12:00", "end_time": "00:00"}
  }
 ]
}
```

There are many more ways to represent the same price and they all come from abusing the segment's restrictions.

Most platforms are able to understand and process all these different implementations, but what do we show to the EV drivers?

1. 0.5€/kWh
2. 0.5€/kWh on Monday, 0.5€/kWh on Tuesday, …, 0.5€/kWh on Sunday
3. 0.5€/kWh between 00:00 and 12:00, 0.5€/kWh between 12:00 and 00:00

They all mean the same thing, number one makes sense, the others probably don't.

A way to solve this problem is to use restrictions only when they are needed.
In the examples above they are not needed because the price doesn't change from one segment to the other.

Example of a correct usage of restrictions according to the proposal


```
{
 "id": "my-tariff",
 "segments": [
  {
   "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}],
   "restrictions": {"start_time": "00:00", "end_time": "12:00"}
  },
  {
   "price_components": [{"type": "ENERGY", "price": 0.60, "step_size": 1000}],
   "restrictions": {"start_time": "12:00", "end_time": "00:00"}
  }
 ]
}
```


Example of an incorrect usage of restrictions according to the proposal


```
{
 "id": "my-tariff",
 "segments": [
  {
   "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}],
   "restrictions": {"start_time": "00:00", "end_time": "12:00"}
  },
  {
   "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}],
   "restrictions": {"start_time": "12:00", "end_time": "00:00"}
  }
 ]
}
```

The tariff above should be represented this way instead

```
{
 "id": "my-tariff",
 "segments": [
  {
    "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}]
  }
}
```

Proposal 2: send the same tariff only once

EMSPs receive and need to manage an increasingly high number of tariffs, as discussed in previous meetings, some of them already need to handle more than 100.000 tariffs.
Most of those tariffs are just duplicates, but they have different ids so they need to be managed.

This is not only a waste from the data transfer point of view but it becomes a synchronisation problem as well.

A tariff needs to reach the EMSP before that tariff is attached to a connector, in OCPI terms, the tariff PUSH needs to happen before the connector PATCH:

```
PUT /tariffs/AA/BBB/my-tariff
{
 "id": "my-tariff",
 "segments": [{
    "price_components": [{"type": "ENERGY", "price": 0.50, "step_size": 1000}]
 }]
}
```

```
PATCH /locations/AA/BBB/my-location/my-evse/my-connector
{
   "tariff_id": "my-tariff"
}
```

This way the EMSP can make sure it will show the right price to their customers.

If a new tariff is created every time a price is changed, the synchronisation above is required.

Systems are not perfect unfortunately, so any of the following can happen:

- A tariff might be pushed (way) after it is attached to the connector via a PATCH
- A tariff might not be pushed at all
- A tariff might not reach the EMSP (because the EMSP system is down or because the EMSP is rejecting it)

What should happen when a tariff is not delivered in time? This is a question for another proposal maybe, but what can we do to reduce this risk?

In a perfect world, the CPO knows all the tariffs it will ever want to use and pushes them to the EMSP (or the EMSP pulls them) at handshake time. After that the tariff module is not really needed anymore, the CPO just needs to send connector PATCHes to change tariffId using one of the ids it already communicated to the EMSP.

But this perfect world doesn't exist, is there still something we can do?
Yes! Reduce the need to push new tariffs (hence reduce the risk of having non synchronised tariffs).

Example:
Let's say a CPO has two tariffs in total:

```
{
 "id": "30-cent-kwh",
 "segments": [{
    "price_components": [{"type": "ENERGY", "price": 0.30, "step_size": 1000}]
 }]
}
```

```
{
 "id": "60-cent-kwh",
 "segments": [{
    "price_components": [{"type": "ENERGY", "price": 0.60, "step_size": 1000}]
 }]
}
```

The EMP will first pull the tariffs after handshake and then pull locations.
Each connector has either tariffId=30-cent-kwh or tariffId=60-cent-kwh.

After some months, the CPO wants to change its prices:

- 30-cent-kwh should become 60-cent-kwh
- 60-cent-kwh should become 90-cent-kwh

Now, the EMP already has 60-cent-kwh, so there is no need to push it again, as there is no need to create a new tariff with the same content but different id.

To change price from 30-cent-kwh to 60-cent-kwh all the CPO needs to do is

```
PATCH /locations/AA/BBB/...
{
   "tariff_id": "60-cent-kwh"
}
```

For each connector that previously had tariffId=30-cent-kwh

To change price from 60-cent-kwh to 90-cent-kwh a synchronisation is required because the EMP doesn't know, yet, the 90-cent-kwh exists. In this case the CPO should:

PUT /tariffs/AA/BBB/90-cent-kwh

```
{
 "id": "90-cent-kwh",
 "segments": [{
    "price_components": [{"type": "ENERGY", "price": 0.90, "step_size": 1000}]
 }]
}
```

And then, for each connector that previously had tariffId=60-cent-kwh

PATCH /locations/AA/BBB/...

```
{
   "tariff_id": "90-cent-kwh"
}
```

If the CPO now wanted to revert the price change back to 30-cent-kwh and 60-cent-kwh it wouldn't need the tariff module anymore, because the EMP already has those two tariffs:

PATCH /locations/AA/BBB/...

```
{
   "tariff_id": "30-cent-kwh"
}
```

For each connector that previously had tariffId=60-cent-kwh

PATCH /locations/AA/BBB/...

```
{
   "tariff_id": "60-cent-kwh"
}
```

For each connector that previously had tariffId=90-cent-kwh.

Bottomline, the CPO should send as many tariffs as different prices they have, this means:

- Only one tariff (and tariffId) saying 30 cent per kWh
- Only one tariff (and tariffId) saying 60 cent per kWh
- …

Proposal 3: do not change already communicated tariffs

OCPI's tariff module allows updating/deleting already communicated prices via the PATCH/DELETE endpoints.

This behaviour introduces a number of challenges:

- Should the new tariff be valid from now? What about charging sessions that were already ongoing when the tariff update came?
- How can the tariff updates be traced? The id is always the same but the content is different.
- What does it mean to DELETE a tariff?

In the spirit of keeping things simple, the CPO could communicate tariff changes as shown in Proposal 2:

1. Create a new tariff when a new one is needed (i.e. a tariff contents never communicated before)
2. PATCH the relevant connectors setting the new tariffId.

This way every tariff change is traceable by looking at the connector PATCHes and each tariff is immutable, meaning a tariff with id 90-cent-kwh always means the same thing.

It will also render tariff PATCH and DELETE useless, simplifying the tariff module implementations.

Tariff Module Common Mistakes

The last_updated field in the location module should be … updated

When a location component (location > evse > connector) is updated, its last_updated field and the last_updated field of all its parents should be updated.

For example: if the status on an evse is updated then:

- evse.last_updated should be updated
- location.last_updated should be updated

Another example: if the tariff_id of a connector is updated then:

- connector.last_updated should be updated
- evse.last_updated should be updated
- location.last_updated should be updated

Basically, everytime a location is updated, independently from the level (connector/evese/location), its last_updated field should be updated.
This is important to make the delta pulls on the location module work properly!

What's delta pull?

OCPI allows getting locations specifying a date_from parameter to avoid downloading the whole locations database from the CPO every time:

GET /locations?date_from=2023-04-01T00:00:00Z

This means: give me all locations having last_updated >= 2023-04-01T00:00:00Z

Why is this a problem? Updates are pushed anyways

Yes and pushing updates should cover most of the cases, but sometimes an update is not pushed or is not received.
So pulling locations as described above, allows the systems to become more resilient.

Suppose that:

- connector.tariff_id is updated today (2023-04-01 at 12:00)
- the related location.last_updated is NOT updated and stays 2023-03-15
- the connector PATCH (updating about the new tariff_id) doesn't reach the EMP (for whatever reason)

When the EMP does a delta pull:

GET /locations?date_from=2023-04-01T00:00:00Z
It will not receive the location updated with the new connector.tariff_id hence it will not know that the price has changed on that specific connector.

Prices are always excluding VAT

Prices communicated via the OCPI tariff module should always be considered excluding VAT.