EVRoaming Foundation
Realising cross-border charging

HEAVY DUTY VEHICLE (HDV) **Smart Charging** (incl. V2G)

A guidance document, describing the possibilities and challenges of different HDV Smart Charging scenarios

The document is written by Contributors of the EVRoaming Foundation. Feedback and comments will also be processed by this group. Organisations that are committed, can join this group by becoming a Full Contributor of the EVRoaming Foundation.

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Contact: operations@evroaming.org

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Management summary

Electric Heavy Duty Vehicles (HDVs) have large batteries and need a lot of energy, energy that is not always sufficiently available at the right time, the right location and with the right power. The large batteries also create opportunities to balance the local energy situation, and with V2X, they can even deliver energy back.

This document, meant to support these conversations, describes the challenges and opportunities for Smart Charging, including V2X for HDVs. This is different from personal vehicles, where the batteries are smaller, the owner of the vehicle is often also the driver, and the financial impact of smart charging for the EV driver and EV owner is a lot less. (The impact on bookings and dynamic update of charging slots is described in the white paper: HDV Scenarios Dynamic Booking; available via: https://evroaming.org/white-papers/)

Taking all the grid connection constraints into account, smart charging for HDVs is not a question but a fact; it must be done as there is often not enough energy available to deliver it with full power at the requested times. Transport Operators (TO) (Fleet owners, HDV drivers, Dispatchers) have demands and requirements. They need to deal with obligatory resting times, charge locations along the roads, and times of arrival and times of departure based on their logistics planning. When they are connected for a longer time at a charge location, the TOs can also offer the benefits of the large batteries to the local facilities. This must all be taken into account.

Two main scenarios are discussed:

- Charging in a short period e.g. along major highways.
- Charging during longer periods at depots, or overnight charging

In both situations smart charging is often possible. In the first scenario, possibilities are more limited to peak shaving, and load balancing. V2X is unlikely because of the limited connection time. Most likely, it will also be the CPO deciding on it, taking into account the boundary conditions from the TO.
In the second scenario, Smart Charging including V2X is possible in many different ways. Although here, too, the boundary conditions must be taken into account, also other parties like the TO or MSP or site owner can influence the way smart charging is done.

The document makes it very clear that at this moment crucial information for good smart charging with HDVs is missing:

- Expected time of arrival (ETA)
- Expected time of departure (ETD)
- Expected amount of needed energy
- Max charging speed the HDV is able to handle
- Min charging power of HDV (to prevent the battery from going into sleep mode, making further charging impossible).

It is possible for this information to be shared when a booking is made, but this is not always the case. For successful smart charging, this information should automatically be shared between the HDV and the CPO and/or the MSP. Currently such a data connection is not in place, nor is there a standard for it. In Europe the role of Electric

Vehicle System Operator (EVSO) is being discussed for the connection between the vehicle and CPO/MSP. A standard way of sharing the above data points is needed.

Smart Charging with HDVs is possible, and is a requirement in many situations. However, several mentioned prerequisites must be taken into account. And for fully realizing the potential of smart charging, parties have to start sharing more information.

Finally besides the technical possibilities and challenges, also economic and contractual considerations must be taken into account, especially for V2X Services. The document emphasizes the need for contractual clarity to enable these advanced services.

Content

Participants of the HDV Smart Charging task group / co-auteurs

Michel Bayings	EVRoaming Foundation / Emobility Consulting
Ian Murdoch	Murdoch Consulting
Gilbert Liu	Shell
Felix Röckle	Daimler Truck
Till Kreft	Milence
Amelie Thuermer	Hubject
Niclas Rinman	Volvo Energy
Nicholas Claaszen	ihomer
Simon Kuhbier	Traton Charging Solutions
Felix Förster	OLI TransIT GmbH
Dennis Möllmann	Ionity
Giulia Gessi	AMPECO
Petar Georgiev	AMPECO
David Edri	Driivz
Oliver Schlecht	Wireless Car
Niek van den Berge	Daf Trucks
William Quan	Fleete Group

1. Background and document setup

This document describes different situations of Smart Charging by HDVs. It gives input for discussions on how and in what situations Smart Charging can take place and the impact on HDVs and the users.

In this document V2X is seen as part of Smart Charging; Smart Charging can be with energy flows in both directions.

The document is written by the contributors of the Heavy Duty Vehicle workgroup of the EVRoaming Foundation.

The reason for this document are the challenges with the grid connections for many charge locations, where there can be situations where there is not enough grid capacity for charging all HDVs. Or situations where for financial reasons it can be interesting to charge the HDVs in a different way.

It starts with a description of pre-conditions for enabling smart charging, then two scenarios are described in this document, each with their context and smart charging possibilities. Finally, some open questions are asked, which can be seen as food for thought.

1.1 Scenarios

In this document two main scenarios are described, to start with and to limit complexity. It is recognised that based on discussions and experience, described scenarios might need to be split and that it is possible that additional scenarios should be looked at and described. (E.g. scenario for shared depot charging. This is not separately described and requires more insight in the usage, context and situation.)

The described scenarios:

1. Interim charging: charging at public / semi-public situations along the road, during short breaks: e.g fast charging along the highways.
2. Charging during longer connected periods: destination charging (private) e.g. at depots situations and charging at final destinations. These can be depots, but can also be other final delivery locations. This scenario also takes into account overnight charging along the highways.

1.2 Impact HDV driving obligations

The document is describing situations where obligated resting times are applicable. In different parts of the world this is dealt with in a different way. This has an impact on smart charging possibilities and limitations. E.g. if charging is done during a resting period, and because of smart charging the charging is finished before the end of this resting period, the HDV might not be allowed to be moved.

1.3 Scope HDV Smart Charging

The scope of this document is about HDVs, charging and dis-charging at depots and along the road.

1.4 Smart charging - definition

A joint understanding of the term "smart charging" is essential to describe use cases and derive the respective data needs. Further, avoiding a mismatch between legislation and technical interpretation is essential.

> *In the context of this document, a smart charging operation is defined as a controlled energy transfer operation that influences actual charging behaviour, which can be unidirectional or bidirectional. The control of energy transfer is coordinated between the Charging Station (CS) and the Electric Vehicle (EV), and is adjustable over time.*

1.5 Smart Charging – Goals

Smart Charging has many definitions and goals. In the context of this document the goals of Smart Charging are:

- Managing energy availability:
  - Managing the situation of grid congestion when there is not enough energy available at a certain moment at a certain location compared to the demand. As a result the amount of available energy needs to be distributed while not every demand can be fulfilled. This can result in long charge times (because of lower charge speed) or requests for charging at different moments.
- Being cost effective:
  - charging at lowest cost, while respecting the energy requirements
    - optimization regarding fluctuating energy supply costs
    - optimization regarding capacity based grid fees or even dynamic energy based grid fees
    - optimization regarding utilisation of given grid connection capacity to mitigate grid extensions and related costs
    - generating revenue in V2G use cases situations.
- Prioritizing charging:
  - Prioritizing vehicles for charging e.g. a vehicle that comes in later might need to leave earlier and requires different priority.
- Predictability:
  - Smart charging makes power and charge time flexible. However, especially in the situation of HDV charging, predictability of getting energy in a certain time frame is still one of the goals.

1.6 Smart Charging – balance between room, usage and benefits of flexibility

HDVs with their large batteries give a lot of possibilities for using them as flexible energy storage. In many cases the owner of the HDV battery will not be the same as the organisation requesting it for flexibility usage. This requires a balance between the 'room for flexibility' (e.g. stakeholder Fleet Operator), the using of that flexibility (e.g. stakeholder: CPO) and the benefits of the using of the flexibility (e.g. stakeholder: site owner, DSO or TSO).

1.7 Smart Charging – what is different for HDVs

Compared to smart charging for personal vehicles we see the following differences:

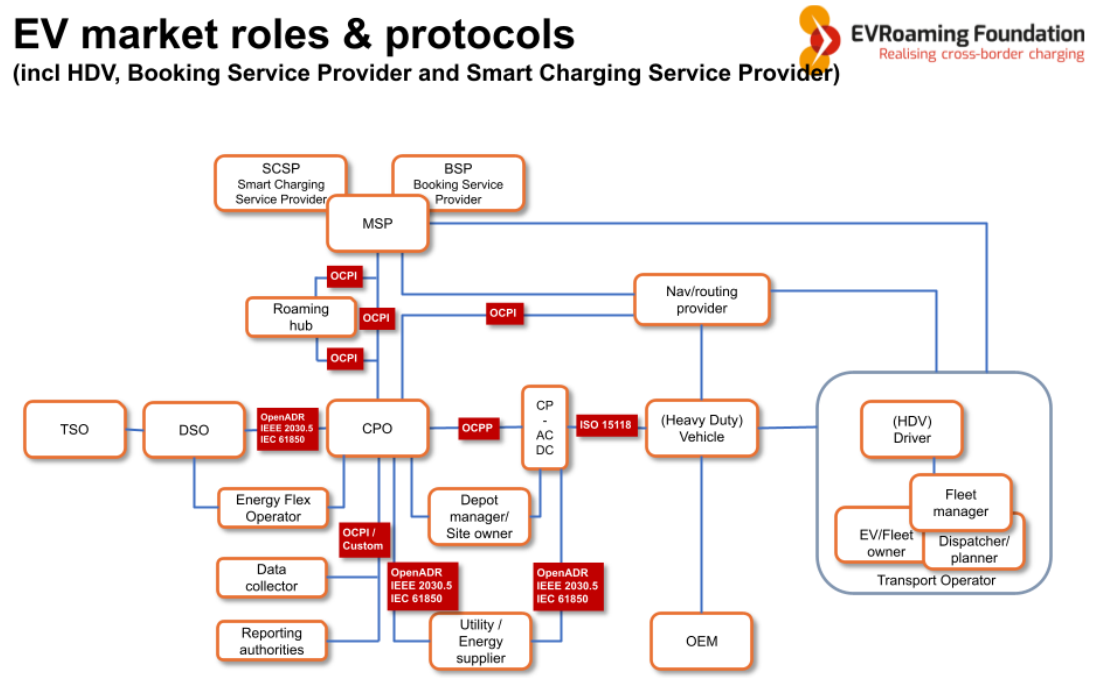
- Different parties involved (e.g. depot owner vs. publicly accessible location owner)
- Different systems involved (e.g. transport management systems, route planning systems, fleet management systems, CMS, EMS, navigation systems)
- Different locations, e.g. overnight charging situations at depots and along the highways:
    - Public overnight balancing of all vehicles at the site - reducing load on the grid, ensuring full charge at scheduled departure time.
- Drive time, arrival and departure time, and other limitations/requirements that are not or much less issues for personal vehicles
- In case of discharging (V2X) at depots, there can be benefits for 3rd parties e.g. depot owners, but also other HDVs that need to charge at those depots.

1.8 Priority for booked charge slots

Based on discussions with market parties, it seems that there is consensus that driver / Transport Operators who booked a charge slot, get priority regarding the power and amount of energy. I.e. in case at a location there is not enough energy or power available to give all connected vehicles the desired amount of energy in desired period, the ones who charge via a booked charge slot should get priority and max available amount of energy above the non-booked charging activities.

1.9 Eco-system with actors

For this document, the following Eco-system is used with the actors mentioned in it. It is created by the EVRoaming Foundation and its contributors. It is not the (only) truth, but a way to show the different actors, which makes it easier to refer to.



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1.10 Role of Smart Charging Service Provider (SCSP) in the eco-system

Smart Charging can be an activity for different roles e.g. Service Provider (MSP), Charge Point Operator (CPO), a combination of these, and it is sometimes also seen as a separate role (SCSP). That makes it hard to make it clearly visible in an eco-system overview. For now it has been put as a role/activity connected to the MSP as it is finally a 'service' which can be provided to operators, EV drivers and/or energy providers and DSO's. This way it is at least visible in the overview.
For this document, the exact place of and if it is an activity or separate role, does not make a difference.

2. Scenarios HDV Smart Charging

To describe the situation for the two scenarios, some pre-conditions are set that are crucial in all situations to decide and execute optimal smart charging.

2.1 Smart charging pre-conditions

To know if and how smart charging can be done, the following information must be known by the CPO and/or site owner:

- Expected time of arrival (ETA)
- Expected time of departing (ETD)
- Expected amount of needed energy
- Max charging speed the HDV is able to handle*
- Min charging power of HDV is/must be known (to prevent the battery from going into sleep mode and it cannot continue to charge).
- Energy prices at a certain moment in time - related to the goal be cost effective

* *Discussion item: if the max charging speed of the booking algorithm differs from the exchanged info between vehicle and charger (part of CCS / MCS protocol), this info needs to prevail / "override" what the booking algorithm sets*

This results in the expected connection time and the minimum and maximum connection time, which gives possibilities for smart charging

3. Scenario 1: Interim charging: charging at public / semi public situations along the road, during short breaks: e.g fast charging along the highways.

Charging HDVs during long trips with at least one charge break requires planning, fast charging and getting enough energy in a relatively short time frame. Possibilities for smart charging are limited. However, because of grid connection challenges, and the high power that is requested, smart charging will play a crucial role in this situation. This is the first described scenario and has the following characteristics (context):

3.1 Context

- Always DC Fast (CCS or MCS)*
- Max needed charging time < 1hour
- Getting the right amount of energy in the right time frame is crucial**. Driver is not knowledgeable enough to make smart charging decisions – at least not in the first years. Although there can be exceptions. This means that:
    - Smart charging decisions should be taken by others or automatically by systems, and
    - The driver must only be informed about and in case of any impact on either:
        - Communicated charge time
        - Communicated booked time slot
        - Charge location or charge parking bay.
- During driving driver tasks should be very limited to avoid any distraction while driving
- Site owner, CPO and HDV owner mostly are different parties and because of that the site owner and CPO do not have own knowledge about Smart Charging capabilities of the HDV using the charging infrastructure.

** = Based on input from the market, charging at public parking places along the road, e.g. highways, during long resting times, will be DC charging*

*** =* In the interim charging scenario getting the requested (booked) or indicated (shared POI-data) power level has the highest priority.

3.2 Smart charging possibilities

In this scenario, taking into account that charging is done during resting times, it is likely that it is fully supplier managed (party offering energy charging service) and not user managed. The supplier in this situation can be the site owner managing it via the CPO or it can be the CPO who is fully responsible and manages it directly.

Based on expected connection time, and required amount of energy, the CPO can decide on load shifting, peak shaving or dynamic load balancing*, taking into account the available energy at a certain moment.

- The energy power can be lower, if for the connection time the max power is not needed
- The energy power can be higher, if the limited connection time (eg. booked time slot) vs desired end SoC requires more power in less time. This can of course only be done if there is enough energy available.

It is unlikely that in this scenario V2X will take place, because the charging takes place in the limits of the trip to the final destination. This leaves no or extremely limited possibilities for V2X.

It must be taken into account that if smart charging results in a shorter charging time vs the resting time, the vehicle cannot be moved because of resting time laws.

(Peak shaving is capping the max energy available for a certain site.*
Load Shifting means that you adjust behind the meter the demand side to take e.g. less energy at a certain period of time, can be a consequence or pre-requisite for Peak shaving.
Dynamic Load balancing is to distribute a max capped demand between the different chargers)

3.3 Pricing

As long as the charging can be fulfilled within the set boundaries e.g. via booked time slot, price differentiation is probably not used and up to the CPO as it will not have impact on the decision by the TO if and how to charge.
With bidirectional charging this might be different because of possible battery degradation, although in this scenario with DC charging bidirectional charging is unlikely to happen.

4. Scenario 2: Charging during longer connected period: destination (private) and overnight charging at e.g. at depots situations, charging at final destinations, charging at protected places along the road

Charging HDVs when they have a longer period available and have more possibilities for Smart Charging. It can be at depots, during loading and unloading, but also in situations for overnight charging along the road and charging at final destinations. More charging possibilities do not mean that it is easier; the opposite. It can be between different operators, different users, differences in parties who benefit and parties who offer flexibility, etc.

This second described scenario has the following characteristics (context).

4.1 Context:

- Can be different locations
    - Logistics centres / transshipment hubs
    - Depot locations
    - Private locations (e.g. individual product/goods delivery for end customers)
    - Public overnight resting locations
- Can be AC, DC Slow (<50kW, incl MCS), DC Fast (CCS or MCS)
- Can be short or long stay including overnight.
- The driver is not knowledgeable enough to make smart charging decisions – at least not in the first years. Although there can be exceptions. This means that:
    - Smart charging decisions should be taken by others or automatically by systems, and
    - The driver must only be informed about and in case of any impact on either:
        - Communicated charge time
        - Communicated booked time slot
        - Charge location or charge parking bay.
- Location owner and the HDV owner can be different, and because of that the control about capabilities of smart charging can be different.
    - In case of a depot the depot owner can also be the owner of the HDVs using the depot, and in that situation they know the Smart Charging capabilities of the HDVs. But it can also be HDVs owned by other party.
    - In case of charging at protected places along the road, the location owner will never be the owner of the HDVs.

** = see paragraph Smart Charging pre-conditions*

4.2 Smart charging possibilities

In this scenario, there are many more smart charging possibilities compared to the first scenario where there is a limited time for smart charging.

Smart charging in this situation can be supplier managed (party offering energy charging service), user managed or a combination. The supplier of the energy will be the site owner managing it via the CPO, or it can be the CPO who is fully responsible and manages it directly. The question here is, who is the user? That can be the EV driver, the Fleet owner, but it can also be the site owner.

To manage and offer smart charging, information from the vehicle (expected connection time, and required amount of energy), but also the requirements from the user(s) and the contracts between parties is important for optimized smart charging.

Load shifting, peak shaving, dynamic load balancing or V2X is all possible.

Along the highways for overnight charging, there can be rules and regulations that automatically result in smart charging, if information about the charging needs and time is known. E.g. If there is an obligated resting period of 8 hours, where the vehicle is not allowed to move (current regulations in Europe), the site owner/CPO can automatically activate smart charging by charging with lower power. In this case the possibility to charge with lower power can have an impact on the business case as it does require more charge stations to charge all HDVs on that location. Dynamic load balancing can be fully automated. This can also have an impact on the charging cost for the Transport Operator (EV driver or fleet owner). V2X is possible, as the vehicle is connected for a longer period of time to the charger. In this situation for overnight charging, which are off peak hours, there is probably no direct need and request for it.

In situations at depots, it can be different. There can be direct interest for smart charging from the site/building owner or user while the party owning the depots can be different then the party owning the HDV. Good smart charging in these situations requires integration into the energy management system at the site; the site must know how much energy is needed and in which time period.

Conditions defined by the CPO and TO including HDV Owner (for discharging) must be clear. The V2G(rid) must be able to adhere to vehicle settings. E.g. a minimum and maximum SoC can be set to avoid deep/over charge. Also the departure time-date and charge target needs to be adhered to, to at least guarantee the required SoC when planning to leave. Maybe even the number of dis/charge starts to avoid too many contactor closures which may lead to durability issues.

Possible situation:

- If there are several charge activities requested at the same time, dynamic load balancing can be initiated by the site owner.
- Depending on the energy availability at a certain moment, also load shifting and peak shaving is a possibility. Also, this can be done by the site owner.
- Batteries of HDVs used for V2X when HDV is not used
    - As this can be seen as a service offering to the site owner, it requires remuneration of the TO or HDV owner by the site owner. Otherwise, it is unlikely that they will allow the V2X charging.

4.3 Pricing

In this scenario, and especially where the HDV is connected for a longer period than strictly necessary for getting the required amount of energy in a short period, price differentiation can influence the charging.

Pricing with or without smart charging can be different and is up to the CPO to decide. It must be clearly mentioned before charging starts. As long as the charging can be fulfilled within the set boundaries e.g. via booked time slot, price differentiation is probably not used and up to the CPO as it will not have impact on the decision by the TO if and how to charge.
With bidirectional charging this might be different because of possible battery degradation.
In roaming contexts, the pre-session price transparency should extend through the MSP to the end customer. Where a CPO offers differentiated pricing for smart charging participation (e.g., a lower per-kWh rate in exchange for allowing load shifting or V2X), this price signal must be communicable through roaming protocols so that the MSP can reflect it in their own tariff to the TO.

4.4 Multi-MSP and roaming considerations

In depot and public overnight charging scenarios, it is common for HDVs from multiple Transport Operators to charge at the same location, each with contracts through different MSPs. This creates a coordination challenge: the CPO must reconcile potentially conflicting smart charging preferences communicated by different MSPs on behalf of their respective TOs. For example, one MSP may have contracted a "guaranteed minimum power" commitment for its TO's vehicles, while another MSP's contract allows full flexibility for load shifting. The CPO's charging management platform must be able to handle these differentiated service levels simultaneously across connected vehicles at the same site.

This multi-MSP scenario should be considered when defining smart charging data exchange requirements, particularly regarding how MSP-specific smart charging preferences and constraints are communicated to the CPO.

5. General remarks to take into account for HDV Smart Charging

5.1 Pre-condition info

In case of a booked charging session, the expected SoC when arriving and expected amount of energy needed is known - according to parties active with bookings and based on first projects and real-life situations. This information can be shared with the CPO at the moment of booking.

Navigation systems in vehicles / Navigation Service Providers also often know the ETA, the expected SoC when arriving and the energy needed to go to their next stop. That is part of the navigation tools. However there is not (yet) a direct connection between the navigation tools/NSP and the CPO.

ISO 15118-20 already has end/desired SoC - but only when you connect - not before (MCS = 15118-20 compatible)

Info via User Interface: The data might also be entered via a User Interface (UI) on or close to the charger Target SoC / Fixed kWh amount. As far as the HDV group from EVRoaming Foundation is aware, these kinds of services and systems do not (yet) exist.

Not every HDV driver and/or electric HDV will share this information automatically. It is likely that even if technically all this information can be shared with CPO, not every vehicle will share it. Result will be that at a location, the CPO knows from certain vehicles the information to manage smart charging, and from some vehicles not.

5.2 Role of Electric Vehicle System Operator (EVSO)

In the European Union there is currently a discussion to introduce the role of Electric Vehicle System Operator (EVSO) that manages the in-car telematics. In that case this requires a connection between EVSO and CPO and/or MSP.
An important conclusion of this document is that a direct link between EV and CPO and/or MSP is missing. This can be done via the EVSO, but requires the setup of a not yet existing protocol between these parties. Such a connection, where information between the vehicle and the CPO is directly exchanged, is crucial for Smart Charging with HDVs.

5.3 Who decides about Smart Charging - different perspectives

There are situations where the decision to do smart charging is logical and can be fully automated, e.g. because of not enough energy at a certain moment at a certain location for a certain demand. However, there can also be situations, where there is not a direct urgent need for Smart Charging as result of mismatch in demand, e.g. in situations where it can be interesting for cost optimization. Question here is: who will decide if smart charging will be done? There can be different interests e.g. from the depot owner vs. the HDV owner and in cases of V2G it can also have an impact on the battery of the vehicle. Smart charging cannot be done until it is clear who is in charge and responsible.

EV / TO boundaries / preferences should be taken into account, within those boundaries the site owner or CPO can decide. This requires that the site owner / CPO must know these preferences. Considering the predictability.

For site owners and CPOs who are managing charging on behalf of site owners, the energy optimization of the site and the optimization of the utilization are important. These must be taken into account as well.

The MSP is often the linking pin between the CPO and the HDV driver/TO. HDV owners/TOs have agreements with the MSP. Because of that the MSP must know what kind of smart charging is offered and activated at a certain location to match his offerings and contracts with their clients (HDV driver/TO).

The HDV driver 'just' wants the vehicle to be charged with the right amount of energy in the right amount of time and should not be bothered with all kinds of smart charging information that they cannot influence.

5.4 Role of Smart Charging platform

We assume there will be smart charging platforms orchestrating the contractual aspects to share pricing information if there is a specific smart charging tariff applied. If CPOs have a smart charging tariff and a standard tariff, MSPs can then choose their pricing model. The MSP can then transfer this into his own pricing models for the end customer.

5.5 Overruling

In situations of personal vehicle charging it is often required, e.g. in tenders, that there is an overrule possibility. That way the EV driver can overrule the smart charging and charge with the max power, within the grid limits. For HDV smart charging we do not expect this possibility as often the HDV driver and the owner of the fleet are different persons/parties with different interests regarding charging.

5.6 Idling fees

Idling fees cannot be expected here if charging is finished 'earlier' than expected. If that happens, the driver cannot anticipate releasing the cable in time to avoid any idling fee, e.g. because of obligated resting times. If such a fee applies, this should only hold for the reservation time-slot and not when actual charging is complete. But this would also be something a CPO determines in their pricing strategy.
During a booked time slot, when the requested connection time is known before the charging, idling fees should not be used.