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Designing a Transparent Smart Charge Point

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Because of the recent emergence of smart cities, an increase in smart devices that run our cities can be observed. Smart algorithms will integrate previously unrelated processes such as charging and car sharing schemes. By designing a concept for a transparent smart charge point, this project explores how we can ensure that the operation of smart devices remains understandable for the general public. Workshops held with municipalities, universities and experts from the field of smart charging suggest that this will be essential, especially when smart devices do not produce the outcome that the public expects. Whether by accident, or purposefully set up, smart devices will not always behave as we feel they should. By designing a transparent charge point, we empower the citizens of smart cities to understand what a smart charge point does and in whose interest it acts with a particular optimization.

Keywords: *Smart, Internet Of Thing, Policy, User Behaviour, Algorithms, Public Interest*

1 Context & background

1.1 Smart cities

Across the globe, public and private parties are building the smart cities and smart infrastructures of tomorrow. They strive to improve the efficiency of systems, reduce costs, improve reliability and offer better services by implementing information technology in our public spaces and infrastructures. This is beneficial for cities and citizens.

However, the increased reliance information technology also carries new risks. We have to ensure that the positive effects of the digitalization movement are fully utilized without sacrificing our democratic values – equal treatment, equality in the decision-making process and freedom of choice – that form the foundation of our society. This is not automatically guaranteed. Algorithms are increasingly used to treat each of us differently, rather than equally. While this is defendable in some cases, in other cases it is viewed as discrimination. The platforms that increasingly 'run' daily life (e.g. Google, Apple, Facebook, Amazon) are governed by a few, rather than all of us. We have no influence on the rules they operate with and freedom of choice becomes an ideal rather than a reality in the current limited player markets.

'Making these infrastructures newly computational has made them much more powerful, but also much more opaque to public scrutiny and understanding. The history of sorting and discrimination across a variety of contexts would lead one to believe that public scrutiny of this transformation is critical.' (Sandvig, 2014, p.3)

Consider a situation familiar to all of us: at times our internet connections appears to be working slower than at other times. There is no way, however, to check whether this is true, much less for appeal.

The Alliander program Democracy by Design proposes design principles that protect democratic values in smart cities and infrastructure. One of the design principles is focused on the algorithms that underpin the actual operation of the smart devices. The optimization resulting from these algorithms can only be justified if it does not undercut our democratic values. But how do we, as users, know that smart devices respect our rights? How do we discern that we are not discriminated against- or maltreated in another way? In the post-Dieselgate era this ceases to be a mere theoretical risk. A second example is the recent 'Greyball' affair, in which Uber has for years engaged in a worldwide program to deceive the authorities in markets where its low-cost ride-hailing service was resisted by law enforcement, by providing a fake version of the app for city officials.

The commercial incentives to make algorithms behave 'strategically', advantaging commercial interests over societal interests or end-user interests are large, and will only get larger.

1.2 Smart charging

The term 'Smart charging' refers to the process of making the timing and capacity of the charging of an electric vehicle dependent on relevant factors such as the availability of sustainable energy or grid capacity.

While present-day smart charging pilots make use of quick straightforward algorithms, with only one or two variables as input, we expect this will quickly become more complex. Smart algorithms will integrate previously unrelated processes such as the charging of electric vehicles and car sharing schemes, using (personal) data from various sources to make an automated decision on whom to charge and when to charge. The reasons for this are both financial (reducing grid connection costs, using car batteries for trading on energy markets) and customer-satisfaction (automatic charging settings based on user agendas)

It is very important to note that there will be situations in which demand for charging will exceed supply. In such situations, not everybody can be charged, and choices need to be made: who will be charged first, and who last?

2 Project goal

In order to ensure that algorithms in smart cities are in line with democratic values and public interests, we, as a society, need to know how they work. One way to protect societal interests, is by making the algorithms in smart devices transparent in their operation (Sandvig, 2014, p.9). Transparency is thus used as a tool to ensure that the device is ethical and lawful.

However, it is unclear what transparency means in terms of smart objects. When the words 'transparency' and 'algorithms' are used in one sentence, this generally refers to open source software. However, most people do not have the specific skillset that programmers have. Moreover, what is the relevance of open source software in public space setting, where even programmers do not have the means to flip open their

laptops and scrutinize the code? And transparency about what, exactly? When it comes to transparency for citizens in the dealing with smart objects in public space, we do not have a perception of what that can mean.

The Transparent Chargepoint project aims to design a concept and build an actual prototype of a smart charging station that is very explicit about what it does, and why it does things in that manner. This should both stimulate the discussion about this topic, and help in answering the question above.

3 Process

In the risk identification phase, workshops were held with a diverse group of participants, such as technicians, ethical theorists, service designers, anthropologists and policy makers. Numerous societal risks were found that could occur as a result of smart charging. These will be illustrated later. Each of these risks involved a party using the smart charging technology in a way that crossed the ethical boundaries of the group. Experts in EV charging IT confirmed many of these risks to be very real for the next five to ten years, looking at the IT of the Dutch charging landscape.

In the design phase, design firm The Incredible Machine was hired for a co-creation process in which a charging station was designed to minimize some of the found risks. Several concepts were developed, which are described in this document. The idea is to give the user insight in what is happening behind the screens. This is done, not with an interest to make the charging product more attractive, but rather as a failsafe mechanism that allows the user to spot if strange things are going on (i.e. why am I charged significantly slower than my neighbor, when we have the same charging scheme?)

In the prototype building phase, a prototype was built. Users can interact with this charge point, and experience how smart charging choices are being made, and how this influences them. This prototype is aimed at stimulating discussion on the topic of smart devices and democratic control.

After the prototype phase, the transparent smart charge point was used as a focus point for discussion with governments, industry and science to collectively answer the question on how we can start embedding transparency in our charging infrastructure right now. If we fail to do so now, we, as a sector will not have an answer by the time the scale-up of charging infrastructure will occur and end up with a non-transparent charging infrastructure.

In a separate work stream, a philosophy student, Jasper Lelijveld, wrote an ethical perspective on the topic of transparency.

4 Smart charging & unethical optimizations

4.1 Smart charging

Smart charging is a process in which the timing and capacity of charging is optimized. Due to the structure of the charging market, several parties are involved in this process. The most important roles of today are: Charge Point Operator, E-Mobility Service Provider, Car manufacturer, Grid operator and Car owner.

Smart charging is a result of the various algorithms that these different roles run at their back-offices, providing each other input.

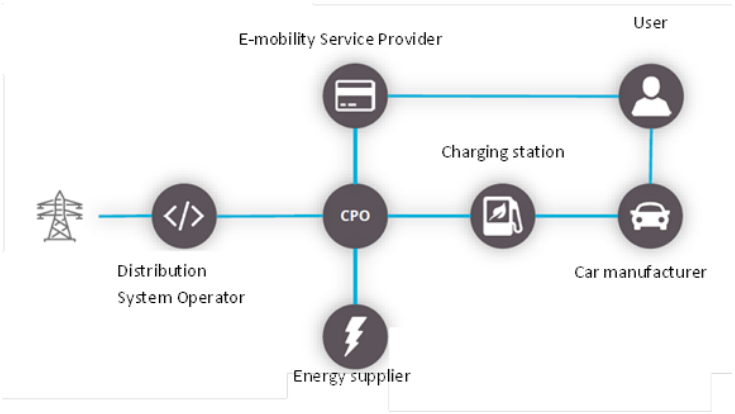


Figure 1: Generic Scheme of Relations between roles in Smart Charging IT

4.2 Future use cases

It is likely that in the future more variables will be included in the optimization and more different parties will provide input to this process. This will lead to optimization of different goals. To imagine future use cases, two workshops were held with representatives from CPO's, grid operators, local governments and academics. Several options came up during the workshops that include:

Social status of EV driver
Charging privileges can be made dependent on the social status of the EV-driver. In a nearby future, workshop participants could envision the charging needs of the working population taking precedence over the needs of the retired or redundant. Withholding charging privileges could be seen as new form of alternative punishment.

Medical
We could envisage some users with medical conditions to take privilege over those who are healthy. Moreover, the charging needs of healthcare professionals could be given more priority than the rest of society.

Mobility
Further optimizations are possible in the domain of mobility. For instance, by taking into account the minimization of total societal traffic time into a charging scheme ('we do not charge for joining traffic jams')

Customer-loyalty schemes
Charging priorities could be influenced by new customer loyalty-schemes (Airmiles) by for instance, retailers ('the more you buy, the quicker your car battery will be charged').

Figure 2: Workshop Illustration on Privacy in relation to Smart Charging

4.3 Optimization turning unethical

While participants felt some optimizations would make sense, they also feel that these optimizations could turn unethical. Governments, market parties, and cyber-criminals are identified as parties which could abuse the power that is created by the smart charging infrastructure for their own purposes.

Governments could abuse their powers in influencing charging schemes. Would it be ethical to put the charging demands of ex-convicts on parole lower on a priority list than those of other citizens? Participants of the workshop feel it would not.

Figure 3: Workshop Illustration on using Smart Charging to collect parking ticket fines

Market parties have several options of abusing their power. They could sabotage rhe devices of competitors (charging stations or cars), or give them lower priorities in charging. These market parties could also implement dynamic pricing strategies that make it very hard for consumers to understand what they are paying and how this relates to the price other participants that are paying. CPOs are in a position to create a lock-in of public infrastructure, making themselves irreplaceable for local governments.

Cybercriminals could use ransom-software, making cars or charging stations unusable unless a fine is paid. They could also use location data to bribe individuals charging at a suspicious location (i.e. red light district). Another option would be to take control over all cars and charge them all at once at existing grid peak hours, causing black-outs. This might be a strategy in cyber-warfare.

Participants of the workshop both felt that future optimizations are likely to occur and that it is likely that this smart infrastructure will at some point be abused by governments, cyber-criminals or market parties, and that either drivers or society at large will bear the costs for this.

5 Transparency & smart charging

5.1 Dimensions of transparency

Transparency can be operationalized in multiple ways. The following dimensions where found during the workshops.

5.1.1 Content

What, exactly is made transparent? We can distinguish between code, input, output, involved parties, and laws and regulations.

Code: the actual source code of the algorithm that is running, or an abstraction of that code can be made more transparent. The actual source code would give most insight in the algorithms workings, but will be very difficult to understand. Furthermore, there is the matter that parties that claim intellectual property rights on the code, cannot be expected to willingly reveal the code. Alternatively, an abstraction of the workings of the algorithm can be given. This will not be problematic from an IP perspective and might be more understandable for human beings. It would function as a 'wrapper for the algorithm' (Korteum 2016) Example:

"Hi, I'm an intelligent charge point. My job is to charge the two cars to my left and to my right. I'm trying to do this as cheap as possible, using as much solar energy as possible, whilst not overburdening the electricity grid. Right now, electricity is cheap, so I'd love to charge both cars as fast as possible. However, the electricity grid is nearing its maximum capacity. So, I can only charge at half speed. Also, the car to the left has indicated it has to leave in a hurry so it will use most of this capacity."

The abstraction would have to include both 1) the goal the algorithm tries to achieve, and 2) the method it is employing for doing so (Rinesi, 2016 interview).

Input: both the types of variables that are used as input as the actual contents of the variables. For instance: Local electricity cable load: 40% or 'Criminal offense record: on parole'.

Output: the amount of kiloWatt the charge station is currently feeding to a particular car, as well as the charging profile for the rest of the charging session. This would give users a lot of insight into what are they actually getting from the charge point, but does not explain why. It does however give users a good indication to spot something is off. For instance: current charging speed: 6kW.

Involved parties: by making the parties that are providing input variables for the charging scheme known to the user, an averagely informed user can infer what goals they might be trying to achieve. For instance: 'The tax office, grid operator and local municipality provide input for optimizing this charging session.' A user who has not paid his taxes, might have a clue why his car is being charged slower than usual, when he knows that the tax office has a say in the charging scheme.

Laws and regulations: a charging station could inform users about the rules and legislations that apply to the algorithm, and the relevant authorities that are appointed by these laws. For instance: 'The General Data Protection Regulation applies to the data that is being used by this charging station. If you feel your rights under this regulation are not respected, apply with…'

5.1.2 Superficiality of transparency

It's possible to make transparent how a charging station should work, when all parties follow the rules. It is more difficult to give deeper transparency

Superficial transparency gives users insight in what is (supposed to be) happening on account of the smart charging algorithms.

Deep transparency would be transparency about the actual code that is running in the back offices of the various parties of the system, rather than the code that is supposed to run. This seems difficult to operationalize, but would overcome the problem of the charging station 'covering up' certain behavior

under the guise of a legitimate explanation. For instance: A charging station signifying to the user that charging limits have been imposed on account of the grid operator, whilst in reality the charging limits have been imposed because of his car brand, or surname etc. This leads to the question: who guarantees that the explanation given to the users corresponds with reality?

5.1.3 Target audience

For whom is transparency given? We can distinguish between three groups:

EV-Drivers: EV-drivers are an obvious target audience.

Non-users: A charging station is an object in public space. Dependent on what type of sensors the charging station employs to read its surroundings, the 'non-users' of the system need to be informed as well. For instance, if a charging station were to use a sensitive RFID reader, or registers MAC-addresses of nearby devices, individuals who are passing by could be affected as well. They would need to be informed that a sensor is registering them.

Supervisory bodies: Transparency could also be given only to a select group of auditors that is tasked with the oversight of algorithms. They could inform the general public by means of trust marks. This might overcome some of the intellectual property problems, as an auditor could be asked not to report details, but only conclusions (not the code, just the verdict whether it works by the rules).

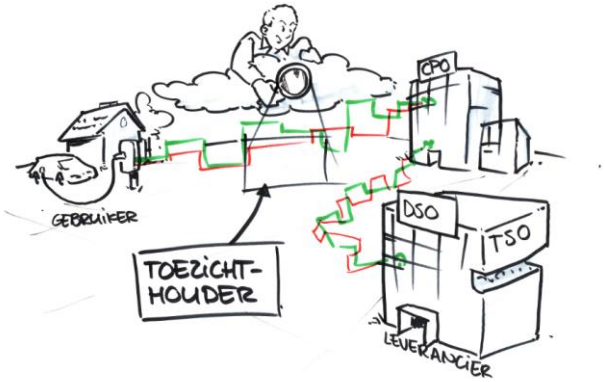


Figure 4: Workshop Illustration on the role of Supervisory bodies

5.1.4 Moment of transparency in relation to transaction

The moment of transparency refers to the point in time at which transparency is given to the user.

Before: transparency can be given before the transaction is started. This gives the user information on whether he wants to interact with a particular charging station in the first place. For instance: "This charge point only uses electricity from non-sustainable sources.

During the charging session, users can also be informed of the choices the algorithm is making in prioritizing the various charging needs of different users.

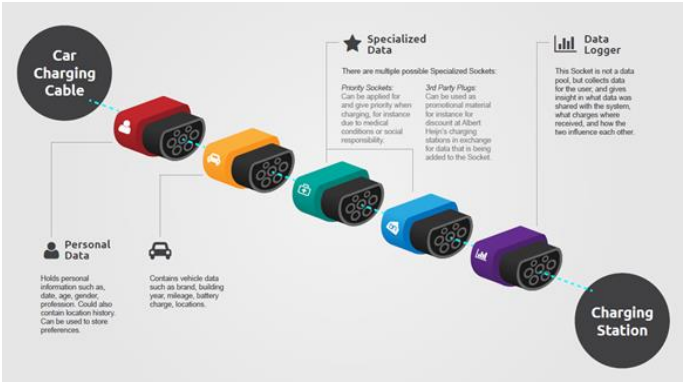
After the charging session, users can be given a 'copy' of the transaction details. This enables them to complain about unfair treatment to the relevant authorities. This copy could be the digital replacement of a paper receipt that people are used to getting at for instance ATMs. The fact that ATMs are equipped to print out receipts, might have been an important factor for the successful adoption of ATMs. At the time, many people unfamiliar with this new device, carefully archived these receipts, just in case irregular transactions happened.

Dimension	Content	Superficiality of transparency	Target audience	Moment of transparency
Option 1	Code	Superficial	EV-Drivers	Before
Option 2	Input	Deep	Non-Users	During
Option 3	Output		Supervisory bodies	After
Option 4	Involved parties			
Option 5	Laws and regulations			

Table 1: Dimensions of Transparency

5.2 Concepts

Based on these parameters, design bureau The Incredible Machine developed several concepts. These concepts illustrate how a transparent charging station could be materialized in the form of a concrete object.



Data sockets

Data Sockets are adapters placed between the charging cable and the charging station.

They act as pools of data that can be accessed by the grid when they connect with a charging station. The Sockets, and the data they contain, are personally owned and managed by the user, protecting their privacy.

Griddy

'Griddy is responsible for charging your car. He also has to work together with the other Griddy's to make sure the grid performs in an optimal way.

He's happy to advice you on what the best way to charge your car is at that moment, and will be grumpier the less you cooperate with him.'

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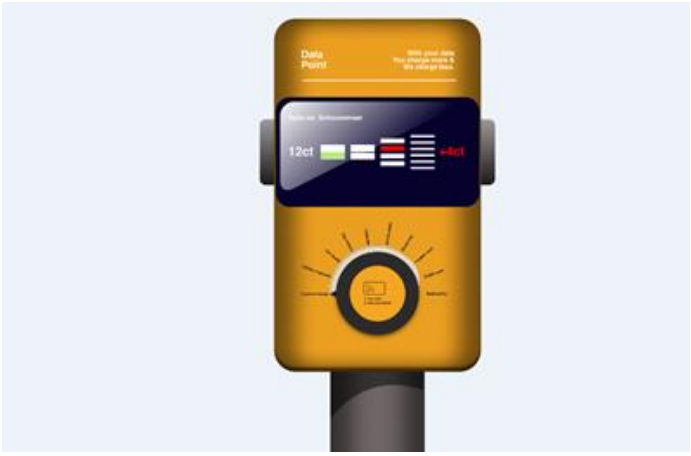
<td> 
</td>
<td>Data Point

‘With your data, you charge more, we charge less’

Users can choose which data they want to share with the charging station. Sharing more personal data allows for a better optimization of the charging process. Visualisation represents the efficiency of the algorithm.

Traces left by the dial show other users choices over time.</td>
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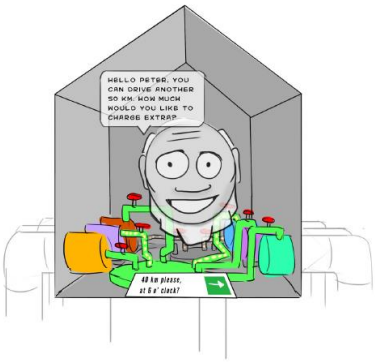
<td> 
</td>
<td>Elder of the Well

Tragedy of the commons

Focus on sharing a scarce resource in a social context.

The social dynamic is leveraged around putting a ‘claim’ on the available capacity.</td>
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<td> 
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<td>Charge Auction

The grid offers certain charge options depending on the state of the grid

and auctions these. Cars are given authority by their owners to bid on

these offers to get the best possible deals.</td>
</tr>
<tr>
<td> 
</td>
<td>Politically Charged

There is no such thing as an objective and optimal algorithm. It always reflects a belief set. Be it equalitarian, libertarian, sustainable, etc.

In 2030, the grid will be governed through a democratic process.

Political parties (fictional) will propose an algorithm, based on public data, reflecting their belief system.

Politicians should be accountable.

An algorithm has a term of a given time,</td>
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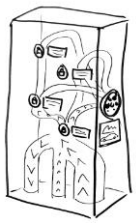
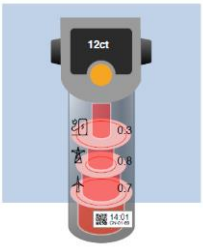
	e.g. one month.
	**Pipes and Connections** Animated pipes show the current and possible flow of charge and can be unlocked with specific data for more flow.
	**Transparent Algorithm** Each step of the energy transport and transformation is visualized. A clock and encrypted key are displayed, so making a picture of this charge point can be validated as a legal document.

Table 2 Various concepts for a transparent charging station

5.3 Conclusion

Transparency can have different meanings when applied to a charging station. The several dimensions that were introduced each have various options – leading to a wide array of possibilities. Based on these dimensions, design bureau The Incredible Machine came up with several concepts how these requirements could be materialized in the form of a concrete object.

For this project the project team chose to focus on **superficial** transparency about the i**nput & output** which happens **during and after the transaction** and is aimed at **EV-drivers.** This design was built into a prototype.

6 The prototype

6.1 Chosen dimensions of transparency

For this project the project team chose to focus on **superficial** transparency about the i**nput & output** which happens **during and after the transaction** and is aimed at **EV-drivers.** This design was built into a prototype. The explanation for these choices are given below.

Superficial transparency: In this project, we aimed to focus on the design challenge: what information should be given to the user for him/her to be able to form judgement about what is happening. The challenge of whether the information given to a user corresponds to what is actually happening in the code (as opposed to it being fake information), was felt to be beyond this project, as it seems either rather technical (dealing with md5 hashes, etc) or organizational (launching a new super visionary body on algorithms, that is tasked with this).

Input and output: We chose to focus on both input and output, but not on the code itself. We found that giving clarity particularly about the output is a concise way to show the consequences for the user. By showing the output for a user *relative* to the output other users are receiving, we imagined people can form an opinion about what is going on. The other options for this dimension were not applied. For the algorithm option, this had to do with our finding that the simple proxy charging algorithm that was used for this project, was already extremely difficult to explain to users. The options involved parties and rules & regulations that could easily be added to the concept, but were not seen as the most challenging design question.

During the transaction: only in an actual transaction are the diverse demands of the various users and the grid requirements weighed up to each other and will a concrete result emerge for the EV-driver. This is the moment in which new situations emerge (cars come and leave, priorities change, etc.), which are taken into account by the algorithm. In order to claim his/her right for fair treatment, transparency after the charging session is important. By giving the user a copy of the transaction - what was promised (kWh and deadline) and what actually occurred (enough kWh? Within deadline?) - he can go to the relevant authorities and complain that he was not treated in a decent manner. In the design, this took the form of a 'replay' option, where users can record a fast forward replay of the charging sessions that occurred with their smart phones. Transparency before the transaction would give a user information that would allow him to decide whether he wants to interact with a charging station in the first place, but was not chosen to focus on.

EV-drivers: are seen as the most obvious target audience for this communication. Whilst the project team also felt non-users and supervision bodies were important, we chose not to focus on these.

6.2 Description

The transparent charging station takes the shape of a 2-meter-tall charging station with three regular Mennekes sockets. A communication matrix informs users of the planned charging schedule, which is represented as a series of colored dots. Each user (socket) is represented by a different color. This way, we can see when individual users' needs will be fulfilled, relative to one another. The matrix width varies over time. This represents the changing available capacity of the grid. So, at one point in time the total capacity for charging cars can be larger than at other times.

Users start a charging session by identifying themselves with a RFID card and setting the amount of kW they need to charge as well as the deadline for this charging session. Dependent on these parameters, the algorithm changes the relative planning of the charging of the three users.

To illustrate how *other* parameters could influence the charging priority as well, a number of RFID charging cards were made. Each of these charging passes has a different priority and deadline setting. These priority and deadline settings were derived from use cases that were conceived in the workshops (see paragraph 5.2). For instance, participants of the workshop expected medical professionals to receive charging priorities in the future. Hence, a charging card was made for a 'Medical Doctor' who is given 'top priority' on account of his charging card.

Some of these cards are positioned on the verge of what is seen as ethical and non-ethical use by workshop participants. For example, the 'Welfare Charge Programme' suggests that users on welfare have a maximum monthly charging allowance.

When a new user arrives at the charging station, or a user changes his deadline, changes his charging needs or identifies himself with a different pass, a message pops up in the matrix, explaining what happened. In this way, users see the input variables that lead the algorithm to change its planning.

7 Key Learnings / recommendations

Focus on transparency, rather than fair algorithms
During the design process, it was very tempting to focus on ways to ensure that the algorithm charges fair. For instance, to prevent unethical optimizations occurring. However, what is fair and what is not fair should be decided in a broader societal and democratic discussion. What you can do, is provide society with meaningful input to make choices on this.

Make involved parties known
For a user with a basic level of an understanding of the world around him, a very concise way of providing him with information is to reveal all parties that provide input for the optimization process. If a user knows

that for example, the Tax Office provides input to the charging process, and is familiar with the aims and purposes of the Tax Office (collect tax), he could infer why his charging process is happening the way it is happening.

Metaphors do not suffice
In the design process, we focused very hard on finding metaphors for what was happening in the digital world. Could we, for instance, explain what is happening with the flows of electricity by comparison to water? We hoped to replace parts of the algorithm by taps, faucets and pipes and in this way, create a 'readable machine' where we could identify by its physical properties what was happening. We could, however, not find any. Even with the relatively simple algorithm we are dealing with, the physical is not sufficient to explain what was happening in the virtual world.

Transparency after the fact
The project team focused on providing information in a relevant setting. In today's information packed society, this contextual relevancy is very important, lest the information get lost in the huge stream of information. The team thought of the charging station as an appropriate channel to communicate information on the charging process. This opposed to, for instance, an app on a smart phone. This decision was informed by our idea that the information is relevant during the charging process. However, during the process we found out that having transparency 'after the fact' is just as important, if the aim is to provide the public with the means to claim their rights (which would start by users complaining and having 'evidence' to back their claims up).

Dealing with concrete constraints
Both the charging station's grid connection as well as the connected low voltage grid have physically bound, maximum capacities. These are relatively easy to implement in an algorithm. The prioritizing that is happening is clear: the charging station chooses between your demands and those of your neighbours'. However, how does one illustrate an optimization that is more abstract (i.e. not a cable) or illustrate when prioritization is happening between you and unknown individuals?

A field test
The designed charging point has not been tested in a real setting. It would be very informative to see how users respond to the information that is given. Do they understand the interface? Do they feel it is relevant? What other information would they need?

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