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An alternative explanation of the persistent low EV-uptake: The need for interventions in current norms of mobility demand

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Abstract
Worldwide, electric vehicles (EVs) are regarded as a key technology in decarbonising the transport sector by integrating renewable energy sources into the grid. Considering the great potentials to disseminate this smartgrid technology, the EV uptake remains low. This tension between the recent years high anticipation of the peakshaving and storage potential of EVs and the associated persistent minor adoption rate is discussed through an in-depth case study of a Danish mobility operator's attempt to test EVs across a variety of Danish households. Considering the operator's ambitious and strategic promotion of EVs lower cost of operation, sustainable aspects and ability to meet driving needs, almost none of the participants wanted to adopt an EV after the trial ended. Corresponding with dominant approaches, the operator reproduced conventional problem framings' focus on technology, economic rationality, and information. However, through an alternative practice-based analysis, this paper critically recommends urgent sustainable mobility interventions to identify the crucial intervention points in the complexes of interlinked social practices to help explain the persistent low EV-uptake. The paper essentially acknowledges the need for policy makers and designers to scale down the focus on technology fix and innovation, and strategical intervene in the current concepts of practice configurations. In particularly, governance of mobility is recommended to involve multiple change agents to design practice-based interventions that target to reframe and reconceptualise the norms enmeshed in current mobility demand.

1. Introduction
The global realities of climate change, ecological and environmental crises, and energy security require the fundamental reassessment of the current unsustainable systems of energy production and consumption (IPCC, 2018). One way that global governance strategies attempt to address these challenges of severe resource depletion is by increasing the production of renewable energy sources. For example, fluctuating electricity generation from wind turbines and solar photovoltaic cells requires flexible load management to optimise the balance of consumption and production (e.g. Darby and McKenna, 2012; Friis and Christensen, 2016). Worldwide, electric vehicles (EVs, referring both to

battery EVs and plug-in hybrid EVs) are expected to reduce the world's dependence on fossil fuels due to their ability to store renewable energy and to offer valuable flexibility to the electricity grid (see e.g. Bakker and Farla, 2015; Kester et al., 2018; Noel et al., 2019).

Besides decarbonising transportation, which emits almost a quarter of the global greenhouse gas emissions and is the main cause of air pollution in cities (European Commission, 2017: 7), EVs offer a range of benefits, such as reducing local pollution, particle, and noise emissions and oil dependency (Kester, 2018). Realising the expected gridpotential of EVs critically depends on the acceptance and willingness of adoption (Bradley and Frank, 2009; Dijk et al., 2013; Kester et al.,2018; Richardson, 2013). However massive R&Ds, EVs continue to constitute a minor fraction of new vehicle registrations and comprised only 0.6% of the total new passenger car registrations in the EU in 2017 (European Environment Agency, 2018). Although the overall general adoption rate remains low, there is notably great variation in uptake among EU Member States, whereas France, Germany, and the United Kingdom are among the countries with the highest increase in absolute numbers today (European Environment Agency, 2018). Most countries in Europe offer financial incentives, such as tax reductions and exemptions.

Outside the EU, Norway has the world's most advanced market for EVs, with over 39% of new sales in 2017 (IEA, 2018a). The Norwegian frontrunner market reflects how government incentives, including subsidies, exemptions from tolls, free driving in bus lanes, and no parking fees have effectively encouraged EV adoption and have successfully maintained the country's leading position. The pivotal effect of national policy regulation became significantly evident in Denmark in 2017, where mixed policy signals (in 2016) followed by gradually reducing tax exemptions, consequently almost stopped the EV sale (IEA, 2018b).

Consequently, a growing body of research and governance approaches recognise strong stable national targets, policy regulations, standardisation, fuel prices, battery costs, supportive infrastructure, travel patterns, and price incentives as crucial fundamental focus areas to increase the volume of sales worldwide (Brown et al., 2010; Dijk et al., 2013; IEA, 2018b; Kester et al., 2018). Although initiatives such as expanding the supportive charging infrastructure, increasing the battery capacity, and adding substantial economic incentives are crucial, this paper confidently argues that critical socio-technical supplementary requires recognition of the complexes of every daily activities. This case study elucidates how EV driving reinforces innovative change of existing (consumption) practices and inappropriately generates new (and unintended) practices. The analysis thus verifies how nonpractice-oriented approaches can increase risks for reproducing and increasing more resource-intensive consumption.

Considering the variety of expected benefits of EVs and the fact that global individual electrification remains distressingly low, representing less than 1% of the global fleet (IEA, 2017), this paper scrutinised a specific case study of an ambitious demonstration project leaded by a Danish electric mobility operator (EMO). This intervention was framed as ‘Europe's largest’. During 2011 to 2014, the first generation of massproduced (battery) EVs was tested in 1578 Danish households living in different parts of the country. The overall aim of the demo was to verify EVs competitive performance to cover daily driving needs (Clever, 2014), a result supported by a variety of studies consolidating the actual capability of EVs to meet the daily mobility demand of consumers (see Franke and Krems, 2013; Khan and Kockelman, 2012; Pearre et al., 2011; Saxena et al., 2015; Simic et al., 2014). However, only 10 of the 1578 participants bought an EV after participating, which was primarily substantiated by concerns about limited driving range.

Today (2019), more than seven years after this research was conducted, massive investments and innovation in the driving range and advanced public charging infrastructure have been made. However, the main obstacle to EV adoption is related to concerns about the driving range (Noel et al., 2019). Upon a comprehensive literature review, Noel et al. (2019) demonstrated that the mainstream approaches among policy makers, industry, and researchers continue to explain the low adoption as entirely connected to psychological, economic, rational, and/or technological barriers. Considering the

dominant focus on ‘techno-fixing’ the challenges, this research subscribes to the growing body of socio-technological approaches' recognition of transition as a much more heterogeneous and complex affair by acknowledging the seamless web of technology and society (Callon, 2012; Geels, 2012). By identifying the neglected social dimensions in the current EV research (Sovacool et al., 2017a, 2017b), wherein the habits and routines are almost overlooked (Rezvani et al., 2015), this research concurs with the increasing quest for social practice-based approaches for alternative policy framing (Shove et al., 2015; Watson, 2012).
The overall purpose of the paper is to provide existing explanations of the (s)low EV-adoption rate with alternative practice-based explanation. By empirically elucidating the links, flows, and time/space relations of interconnected practices, the aim is to add more comprehensive understandings to recognise the need to intervene in the complex system of interlocking (mobility) practices (Sheller and Urry, 2000; Urry, 2004; Watson, 2012). Thus, this research contributes with analysis that goes beyond the dominant focus and ideally encourage future mobility interventions to focus on how to re-evaluate and reconfigure the interconnections between the temporal and spatial relationships of contemporary (mobility) practices. The core assumption is that future mobility transition requires redesigning the system to encompass a range of green alternatives to private car-based transportation. Thus the core assumption is that the future transition demands widespread integrated innovative mobility solutions, such as shared mobility (ride and car sharing), autonomous mobility, and concepts based on Mobility-as-a-Service (MaaS), which have attracted much attention the last 5 to 10 years (Jittrapirom et al., 2017; Utriainen and Pöllänen, 2018).

Disseminating individual private-owned EV adoption is therefore only considered as one significant technology solution among a variety of others. Essentially, this paper draws on the principle that long-term sustainable mobility solutions must be tailored to the everyday lives of citizens. Changing the current derived mobility demand requires policy framings and interventions (regardless of private and collective-based (electric) transport modes) that challenge powerful notions and meanings related to car driving.

The following section (2) clarifies this paper's analytical framework by introducing Spurling and McMeekin's (2014) practice-based intervention framings. The next section (3) presents the empirical data and methodological approach, which is followed by an introduction of the strategy and design of the case study (4). The following analysis (5) examines the studied intervention through the concepts of the alternative lens of practice-based policy framings. Based on the core analytical findings, the discussion (6) confirms how radical transformation requires alternative approaches to accelerate EV adoption and aims to provide recommendations for future sustainable mobility interventions.
Finally, comes the conclusion (7).

2. Analytical framework: intervention in mobility practices

In opposition to the dominant technologically and psychologically oriented governance approaches, social practice theories do not reduce EV adoption to a matter of individual attitudes, behaviours, or choices but to people's performance of mobility practices (Halkier and Jensen, 2008). To achieve adequate socio-technical change, this theory highlights the importance of recognising how social (driving) practices are carried out and performed by practitioners across time and space. Confronting well-established traditional approaches problems of targeting sustainable consumption, an increasing number of scholars propose practice-theoretical approaches as a new and distinct social ontology to better inform governance interventions (Shove et al., 2015; Spurling and McMeekin, 2014; Spurling et al., 2013; Strengers, 2013; Watson, 2012). Instead of focusing on efficiency, they suggested addressing the pivotal critical question regarding ‘What is energy [demand] for?’ (Shove and Walker, 2014) and thus focusing on how the current demand for mobility is produced (Shove et al., 2015; Spurling and McMeekin, 2014; Watson, 2012). From this lens of theory, car drivers are ‘carriers’ (Reckwitz, 2002) of mobility practices that change, reinforce, and reproduce the current mobility patterns (Shove et al., 2012). Despite various interpretations of the elements configuring social practices (Gram-Hanssen, 2011; Reckwitz, 2002; Schatzki, 1996; Shove et al., 2012), this paper operationalises Shove et al.'s (2012:14) simple conceptualisation of the three interdependent elements: materials, competences, and

meanings, which comprise sustained practices over time through mutual interdependencies configured through the cumulative moments of performance (Shove et al., 2012; Watson, 2012).

2.1. Practice-based electric vehicle intervention framings

Reflecting on the limited change potential and failure to deliver the anticipated carbon emission reductions of the mainstream conventional mobility policies, Spurling et al. (2013: 2) developed three alternative practice-based mobility intervention approaches: (i) 'recrafting practices', (ii) 'substituting practices', and (iii) 'changing how practices interlock'. These three alternative framings distinguish between the types and scales of ambition within the transport policy in the United Kingdom. Below, the three different policy interventions are transferred to this research field by exemplifying how EV adoption could potentially be accelerated.

The first suggested practice-based problem framing, recrafting practices, seeks to change the elements of existing practices. Realising the expected decarbonising potential might entail systematic intervention in the existing elements, configuring resource-intensive combustion car practices. Transferred to EVs, recrafting the *material* of combustion cars could require shifting the combustion engine to an electric engine, providing practitioners with *competences* to manage charging electricity at home (during low peaks) instead of fuelling vehicles at petrol stations, and reinforcing the *meaning* of EV driving by underpinning the green and sustainable attributes related to electrification. These policy interventions target reframing the purpose of all three elements to reduce the quantity of combustion cars but are not changing the scale and extent of the current mobility concepts (Spurling and McMeekin, 2014).

The second problem framing comprises substituting practices, which suggests policy interventions to discourage and replace the current unsustainable practices by substituting them with more sustainable alternatives. To change the balance and competition between combustion cars with EVs requires intervention in both counterparts of practices at the same time (Spurling and McMeekin, 2014). As specific examples, the Municipality of Copenhagen (2012) has substituted conventional parking spaces with charging stations earmarked only for EVs and implemented a variety of initiatives to encourage new recruits to commuter cycling and limiting car driving (Municipality of Copenhagen, 2011). Hence, encouraging competition between the two transport modes due to time, space, and resources is intended to reduce less sustainable practice.

The third and most ambitious problem framing is to change how *practices interlock*. These forms of interventions alter the sequencing and/or synchronisation of how interconnected social practices are constituted and embedded in material arrangements. Based on the considerations of relations, connections, and links between 'bundles' and 'complexes of practices' (Shove et al., 2012), Spurling and McMeekin highlight the need to change the interlocking between existing infrastructures and institutions, which determine where and when everyday activities take place. Attempts to alter the level, scale, and character of the current demand for mobility put the 'negotiability of need' on the policy agenda (Spurling and McMeekin, 2014). According to the concern regarding the EV's limited-range capacity, the norms around the demand of mobility require a redefinition. Realising the vehicle-to-grid potential of EVs influences (and demands reshaping) existing infrastructures, institutions, and sequences of everyday driving activities. Regarding this, interventions need to acknowledge how changing (driving) practices crucially influences the entire system of practices of which driving is a part.

Corresponding to Spurling and McMeekin's (2014) practice-based intervention framings, Watson's system of practice approach demonstrates how a particular mode of mobility, such as driving, only can recruit and retain practitioners as long as other co-dependent practices continue to be performed. This illustrates how adequate decarbonisation requires direct and/or indirect change in the complexes of mobility practices, which might include practices such as working, going to school, shopping, visiting friends and family, maintenance, and leisure activities (Watson, 2012). A systemic configuration of linking practices together contributes to enabling and sustaining particular socio-technical modes of 'doings' (Shove et al., 2015). Modifying practice elements that comprise driving will therefore affect related practices in the automobility system (and vice versa). In this regard, a system of practice-

based analysis would presumably recommend substantial change to intervene in the current complex system of social practices. Practices are essentially (historically) contingent, which means that they are open to develop, re-evaluate and change over time. Before applying the theoretical conceptualisations in the later analysis and the following discussion, the following section illuminates the mix of data collection, followed by an extended presentation of the design and strategy of the studied intervention (Section 4).

3. Qualitative methods

This case study builds upon a variety of qualitative methods. The basis of the empirical material is the qualitative interviews with relevant informants (n = 20) collected over a period of two years. The first round of empirical material was collected during the summer in 2012 and included semi-structured interviews with participants (n=8) living on the outskirts of two middle-sized towns in a declining region of Denmark. In addition to EV test-driving, this group of participants also participated in another smart-grid project. This further aimed to test how much 'time-of-use pricing' combined with EVs influenced the participants flexibility to change their consumption patterns (for a more in-depth analysis, see Friis and Christensen, 2016; Friis and Gram-Hanssen, 2013). These interviews took place in the participants' private homes and primarily aimed to explore how the combined trials influenced the participants' everyday consumption practices (Friis, 2016).

The next round of interviews comprises three focus group interviews with participants (n = 8) living in the northern suburbs of Copenhagen. These were collected in the winter of 2013. Whereas the first sample was recruited due to the combination of smart-grid trials, these households were recruited through their workplaces and represented a higher middle class due to their common professional backgrounds (working as doctors or nurses in three hospitals), and thus shared similar cultural and socio-economic 'capital'. The common socio-economic characteristics made it easier to shape valuable trust relations within the groups and thus became valuable catalysts for opening discussions about meaningful driving. In accordance with Halkier's (2010) observation, the social interaction in the groups created an atmosphere allowing normative positions and thus proved a useful indicator of the current powerful discourses. A further aim was to observe whether this group of test drivers (that were not provided with economic incentives) were flexible to charge the EVs at night to peakshave the fluctuations in the grid.

Participants were selected according to diverse parameters, such as gender, age, education, income, marital status, household size, number of children living at home, and daily driving distances. The idea of ensuring sample diversity was that this would contribute to a fuller understanding of the complex nature of households' interactions with EV technology. The access to the socio-economic data was provided by the EMO.

Further qualitative interviews were conducted with the key stakeholders from the EMO, which aimed to cover their views related to designing the intervention from both a practical and strategic perspective. Moreover, the policy intentions, strategies, and rationales informing the allocation of public financial support to the demo project were achieved through interviews with funders from the Danish Transport Authority. Overall, the interviews with 'professionals' covered the rationales in this strategic mobility intervention. All interviews have been fully transcribed and lasted between 1 and 3 h. Inspired by Spradley (1979), the interview guides were designed to obtain insight into the participants' perception of meaningful (EV)driving as well as specific mobility performances, daily temporal rhythms, habits, routines and electricity consumption patterns.

Other empirical data were collected through attendance at information meetings connected to handing over the EVs to participants, which provided further insight into the strategic rationales and tools of the operator. In particular, interactions between the participants and the operator were valuable in exposing explicit and hidden expectations and prejudices. The participants were obliged to blog weekly about their experiences related to being a 'test pilot', which have contributed valuable knowledge about the participants' challenges, advantages, and experiences of EV driving.

In general, this relatively small sample is considered as an unrepresentative group (Flyvbjerg, 2006), which is connected through a shared interest in testing EV technology. Rather than producing 'generalizable' and 'representative' knowledge, this data serves to illustrate the complexity associated with attempts to integrate and adopt EVs in a contextual situation. This approach proved valuable to unpack the complex interrelations of social practices that are critical to inform the design of comprehensive and workable user-friendly interventions. By scrutinising happenings, doings, meanings, and rationales in particular contexts of time and space, the interconnected social practices appeared. The specific design of the intervention (described in the following section) has some obvious consequences for the scope and effect of the trial. For instance, requirements for participation, such as living in a detached house in the outskirts of larger cities, have obviously limited the knowledge production for a wider generalisation and thus for the transferral of the results to urban areas.

The sample of participants represents an active segment of households conventionally referred to as 'front-runners' or 'first adopters'. This is why, this inquiry expects that the participants' experiences of challenges and disruptions associated with integrating EVs, also will appear (and maybe even stronger) among less dedicated, engaged, and informed households, a segment that according to Flyvbjerg can be categorised a "critical case" (see Flyvbjerg, 2006:230). Considering the last decade's massive investments in EV technology, this investigating of participants' perceptions and experiences related to test an eight year old technology could easily be criticised for being obsolete and even inadequate for present policy framing.

Nonetheless, the persistent difficulties to accommodate adoption substantiate how this case study is perhaps more pertinent than ever before. The considerable technology improvements clarify precisely how technology fix and innovation merit supplementary explanations. Thus, despite being aware of limitations and premises derived from a qualitative (old) case study approach, this research evertheless approve that studying contextual-bounded micro practices of households is crucial to inform and design future interventions to accommodate change by recognising the complex interconnected practices. The core concern of conventional approaches limited potential for radical change seem apparently to reverberate current governance level, regarding newly initiated practice-based projects such as e.g. ENERGISE and SIMS, which respectively are funded by EU and the Innovation Fund Denmark (see http://www.energise-project.eu/ and https://www.sims. aau.dk/). (see Table 1).

Table 1: Overview of the data

Method	**Time and space**	**Selection**
Individual interviews (n = 8)	Collected in the Summer 2012 in the cities Sønderborg and Åbenraa	Test pilots were offered pricing schemes. Great variation on socio-economic parameters.
Focus group interviews (n = 8/3 groups)	Collected in the Winter 2013 with test pilots living North of Copenhagen	Test pilots without pricing schemes. Participating through the working network.
Change agent interviews (n = 4)	Collected in Copenhagen 2014 at the EMO and Ministry	Project owner, project coordinator and funders from the Danish Transport Authority.
Participant observation/blogging and field notes	The data was collected through information meetings; test pilot blogging on Facebook; field notes and sketches after interviews.	

4. The mobility intervention: design and strategy

The EMO was founded by two Danish energy companies who teamed up in 2009 to create the condition for the electrification of transportation in Denmark. Today, it is owned by major Scandinavian

energy companies focusing 100% on EVs and charging. Consequently, the overall aim of the demo project was to change the general negative perceptions of EVs among Danes by collecting comprehensive, verified data on the competitive performance of EVs. Thus, the demo was designed to be a crucial instrument in the EMO's long-term commercial strategy of rolling out EVs and establishing charging stations nationwide and abroad. The comprehensive knowledge was thus supposed to ensure long-term user-friendly sustainable solutions to realise the future smart-grid technology potential of EVs for storage and 'peak-shave' fluctuations (Clever, 2014). Based on GPS data, the demo project concluded that the tested EVs accommodated the daily driving needs and in general have a huge smart-grid potential due to storing electricity when parked (Clever, 2014). In addition to the private company's own funding and sponsorships from partnerships (private car manufacturers), the demo project received public financial support from Danish municipalities and ministries.

The roll out was realised in a particular political context characterized by the Danish Government's (2013) target to be independent of fossil fuels by 2050 and their associated vision to accomplish 50% renewable energy by 2025 with great assistance from the storage capabilities of EVs. The then-political instruments to stimulate the EV market penetration were exemptions from vehicle registration, weight, and owner tax (Registration Tax Law, 2014) and providing EMOs with the ability to give participants a discount on the electricity expenses associated with charging.

The selection of test drivers was open as long as they fulfilled certain requirements, such as being willing to pay the excess costs associated with refuelling the EV batteries at home, owning a car in advance of participation, and living in a detached house. Further, the assignment obliged the participants to pay additional electricity costs, use the EV as the household's primary car, blog weekly about their experiences, complete a driving book by registering the details of each trip, participate in public events, fill out questionnaires, and so on. The core aim was to collect EV driving experiences from a broad cross section of households, particularly living in the outskirts of larger Danish cities. The EVs were tested in 24 Danish municipalities by eight private companies; thus, the operator cooperated with a variety of Danish public and private actors to promote, anchor, fundraise, and disseminate EVs. The data comprised both 'hard' and 'soft' data. The hard data consisted of the electricity consumption, load patterns, driving performance, and range extension to qualify valuable forecasting, whereas the soft data included the test drivers' personal reflections, number of passengers, weekly driving targets, and daily blogging.

The tested vehicles were manufactured by the following brands: Peugeot Ion, Citroën C-Zero, Mitsubishi iMiev, and Nissan LEAF. All were categorised as the first generation of mass-produced manufactured EVs. Although the EV technology has been substantially advanced since then, particularly regarding battery capacity, the EMO concluded (based on GPS data) that the tested EVs (2011–2014) covered 98.9% of the driving needs. Verifying that only 1.1% of the test participants' trips (within a year) necessitated a conventional combustion car (Clever,
2014: 130), the low adoption rate today (2019) substantiates that the time has come to go beyond the dominant explanations of limited driving range, and simple questions of changing people's rational mind set.

5. Analysis: framing meaningful EV driving

This analytical section assesses the EMO's strategic approach to increase EV uptake, investigated through Spurling and McMeekin's (2014) three practice-based policy framings. This forms basis for the following discussion of how distinct and practice-based problem framings potentially can inform, redefine, and construct adequate interventions to provide sustainable mobility transition.

5.1. Reproducing mainstream adoption approaches

Branded as Europe's largest EV demo, the EMO aimed to 'break down' negative images associated with EVs by eliminating the myths about EVs as being unsafe, costly with a limited-range capacity and

an unclear charging infrastructure. In the final evaluation report, the operator verified that the tested EVs sufficiently covered participants' driving needs (Clever, 2014), as proudly proclaimed by the project leader:

> *We demonstrated that the EVs worked (…) generally the trial has been a success (…) we have broken down several biases which is superb, since that was the primarily target for the project.* (Project leader from Clever, 2013)

Overall, the EMO underpinned that the collected data provided sufficient convincing results about EV's compatibility and thus declared a huge potential for distribution. The paradox of the rejection among the participants was explained by the professionals as a consequence of the technology's too high purchase price, insufficient driving range, and limited selection of EV models. The funder clarified this assumed causation, as follows:

> *It [EV adoption] has gone much slower than they [the EMO] had expected. The selection of vehicles needs to be greater. The range is too limited. It is a clear limitation. Now, in 2014, we get more models from Renault, Volkswagen, and BMW (…), people are creating a demand, [and] when there is a greater supply [of EVs], then it will be more likely that there is a car that will suit them.*
>
> (Funder from the Transport Authority, 2013)

Besides technological fixes and innovation, the above explanations co-produce dominant policy trends and assumptions about adoption automatically will increase when the EVs offer performance competitive with the conventional combustion cars. This further illustrates how the technology-fixing approach obviously reduce mobility as a matter of moving goods and bodies from a to b, and thus problematically neglect the diversity of meanings and complexity of practices related to driving.

5.2. Attempts to 'recraft' practices

Although the mainstream techno-rational approaches evidently dominate the agenda, the EMO nevertheless attempted to recraft existing driving practices. Obviously, the intervention replaced the combustion engine with an electric battery (material), and the experimentation of testing prompted more energy-efficient driving skills (competences). Most distinctly, the intervention pushed through a substantial engagement strategy (meaning) consisting of various elements. Besides obligating participants to promote their driving experiences throughout social medias, the operator further committed people to report a variety of data e.g. to ensure the "right" behaviour regarding night-time charging. In addition, considerable information was disseminated through pamphlets, brochures, a trial website, and participant information meetings (which were obligatory) to underline the overall advantages and potential of EV driving. The following promotion text clearly illustrates how the operator attempted to modify the meaning of EV driving by framing it in terms of green and economic benefits:

> *As an EV driver, you positively stand out. Driving an EV increases your comfort and safety and reduces your operating costs. As an EV driver, high fuel costs become the past and service and maintenance requirements are minimised. Furthermore, the EV plays a significant role in increasing available green transportation and reducing noise and air pollution in cities (…). With an EV you help contribute to Denmark reaching its target of getting rid of fossil fuels by 2050 (…) you will not only make a difference for the environment and your wallet – but you will also increase your comfort through your driving experience.*
>
> (Promotion text from a Clever pamphlet, Clever: 2011)

The operator's interest in demand-side experiences and interests in consumer practice performance indicates that the intervention went beyond a purely technological fix. Nevertheless, the operator repeatedly underlined considerable information and driving range advancement as the core instruments to increase adoption. Although the intervention aimed to reframe all three elements, the general resentment against EVs underpins Spurling and McMeekin's (2014) point that this first practice-based framing is not changing the scale and extent of the current combustion car regime.

5.3. Lack of substitution and changing how practices interlock

The operator had no ambition to subjugate and/or discouraging the practices of existing combustion driving. Instead, the EMO continued to compare the EV's attributes, behaviour, and choices with conventional combustion cars characteristics and thus reproduced conventional driving practices as the success criteria. By focusing on convincing arguments about the EV's ability to cover 98.9% of participants mobility needs, the intervention coproduces the current mobility demand. Nevertheless, the EMO given the rhetoric about the compatible performance of EVs, to some extent acknowledged a need to challenge the 'balance of competition' between the combustion car and the EVs (Clever, 2014). Both the project leader and project coordinator conceded the need to abandon the notion of unlimited mobility, clarifying that:

> *In Denmark, people buy cars according to their marginal needs. It's a known phenomenon. You buy a car according to the need to drive to the local waste recycling station two to three times per year, or for a longer vacation, or for skiing once per year.*
> (Project leader from Clever, 2013)

Considering the need for socio-technological transition, the above quotation remained on an abstract level without further action beyond it or visions about how to get there. On a conceptual level, the EMO explained that the low adoption not necessarily relates to limited driving range but perhaps rather as a matter of the norms around mobility, implying unlimited perceptions of individual personal freedom and flexibility. This indicates an extent of awareness of the powerful social conventions embedded in the current mobility regime.

In general, the operator was critically unaware of the link between the current mobility demand and the accomplishment of a wide range of interlinked complexes of practices, such as work, school, shopping, leisure, and so on. Further, the operator did not reflect upon whether EVs lack of capacity for performing the "extremes" extra kilometres could increase demand for a second or third car (like in Norway). Rather than disrupting resource-intensive driving, the above analysis illustrates that the intervention reproduced the existing demand of mobility. In the following discussion, further empirical findings are presented to add recommendations for future policy framings in order to accomplish the peak-shaving potentials of EVs.

6. Discussion: designing sustainable mobility interventions

6.1. Interventions need to acknowledge the complex of interlocked daily mobility practices

Based on the perceptions of sense-making and meaning related to EV-driving among participants (from the focus groups), the following discussion aims to clarify how driving (and charging) are interconnected (and interlocked) with other daily practices, such as working, social care, leisure activities, food-provisioning practices etc.

All the interviewed EV drivers linked car driving with the need for daily commuting, moving goods, leisure activities, relaxation time, and typically framed driving with cultural conventions of the car as the epitome of individual freedom, convenience, comfort, flexibility and safety (Freudendal-Pedersen, 2009; Sachs, 1992; Urry, 2004). Therefore, sequences and the time connected to the duration of daily driving patterns played a crucial factor in scheduling and planning the bundles and complexes of interlinked everyday domestic practices. As Pantzar and Shove (2010) observed, practices are conditioned by multiple temporal demands of these practices. Moreover, Southerton (2012) recognised how this 'temporality of practices' is configured by collective and personal temporal rhythms.

This explains why the participants' core objections to EV driving were associated with their loss of control due to unexpected EV-related events that disturbed and/or disrupted their individual temporal

organization of daily practices. Some participants associated daily commuting with relaxation time spent between busy mornings and working and thus characterised driving as the advantage of having some valuable time on their own in the car (also observed by Freudendal- Pedersen, 2009). This relaxation time shares parallels with Southerton's (2003, 2009) concepts of cold spots, referring to periods with low activity associated with 'quality time', which is an antithesis to hot spots that are intense in the number of activities within limited periods. These discursive stories underpin how car driving is more than just a material transporting 'goods' from A to B by also providing a space for recharging personal 'batteries'. Anxieties related to running out of power, being uncomfortable due to the cold (when the vehicle's heating was turned off to conserve battery power), and unreliable engines threatened these valuable 'in-between-hot spot situations'. The following quotation underpins how temporalities and scheduling of EV driving intersect in the wider systems of practices (Watson, 2012), and therefore plays a significant role in the rejection:

> *All these thoughts of logistics. I can't drive as far as I need to do the things I've planned in my everyday life (…) I have to think much more about my transportation. I haven't had the spontaneity to take a detour when someone calls me on the road, and things like that. All the time I had to plan, 'Oh all right, what am I going to do today? Which car should I take?' I'm simply used to expecting that the car isn't something that I have to think about, right? It's just there and simply works. It has been way too difficult thinking about these logistics.*
>
> (Test pilot, Bella, 45 years)

Moreover, the quote illuminates how EV driving crucially competes with other everyday practices for time, and further how personal scheduling and collective institutional rhythms challenge the ability of EV driving performances to take hold. In particular, rescheduling everyday practices due to the need for regularly recharging of batteries disrupted the tightly coordinated activities. None of the interviewees were willing to sacrifice, reschedule or change the coordinated bundles of practices. Indeed, EV driving was shown to require far-sighted planning skills, as stressed by another participant:

> *When I get home there are very few additional kilometres to run on, which means that you really have to consider what to do next (…) some days I had to drive home early from work to recharge the battery and get it ready for my evening activities.*
>
> (Test pilot, Cevin, 53 years)

In addition to the systems of practice approach (Watson, 2012), Southerton's concepts of hot spots, cold spots, and 'harriedness' are useful for understanding participants' rejection of EV driving due to the lack of flexibility and reluctance to peak-shave. Significantly, the feeling of 'harriedness' relates to incompatibilities to be mobile (caused by the limited battery capacity) between fixed institutional events. The degree of acceptance differed considerably with family size, number of children, commuting needs, place of residence, etc. For instance, families with young children adhere to school/work opening hours (institutional rhythms), which highlighted how children's families are particular challenged to integrate EVs in their hectic everyday lives (see e.g. Friis and Christensen, 2016; Nicholls and Strengers, 2015). The ability to fulfil personal temporal strategies and perform activities at desired times illustrates how the mobility demand is linked to individual socio-demographic and specific contextual conditions.

The following extract from a focus group discussion clearly clarifies how tight organisation of daily planning and scheduling is required to complete a range of social practices:

> *Maya: I go to yoga once per week in the evening a few kilometres away, which I couldn't go to without a car.*
> *Lily: So, in fact, the EV has a great capacity for driving to and from work, but it's all the other things you have to do in your daily life.*
> *Maya: Small things matter.*
> *Lily: Which makes it complicated to….*
> *Interviewer: So, commuting is not the challenge?*

Lily: No, it's everything else.
Maya: It's all the small things. You have to go shopping for groceries, then you suddenly need some milk, and it's definitely a must to have power [in the battery] for that.
Lily: But also to, oh yes, then your old mother calls and asks you to drive by and pick her up.
Maya: Sorry, unfortunately, I do not have power for that (…) Yes, you can't make a spontaneous detour, it [the EV] can't.
Interviewer: So, we can't be as impulsive, you could say?
Maya: The flexibility disappears. Although I have a very structured day, it's simply too annoying to be tied up [dependent on the EV].

This conversation shows how driving is integrated with many other daily practices and clearly demonstrates why the (unreliable) performance of EV driving frequently disrupted these systemic arrangements. Significantly, this indicates how EV driving modified the configurations of these systems (both temporally and spatially), which none of the participants found meaningful. Further, the dialogue shows how the current concept of mobility are strongly associated with comfort and the individual freedom of being flexible to govern and reschedule everyday practices when necessary.

Further than recognising the configurations of practice bundles, this empirical material underpins why mobility actors should be aware of not proclaiming too-high expectations of a test technology when framing and implementing new technology. That the operator successfully promoted the EVs as compatible with the existing demands of driving appear clearly due to three winter test drivers perceptions of the technology as too insufficient, unsafe, uncomfortable, and stressful:

Bella: I have not the slightest doubt that we won't have an EV after we've tried it. I have been freezing crazy much. (…) Holy shit you're freezing, and you can barely get warm when you come inside again because your hands and feet are simply deep frozen. You get so cold because of your eagerness to save as much heat as you can in the car so that you can drive as far as possible. We've been sitting with blankets and duvets and wearing both hats and gloves to ride from Allerød to Copenhagen … 35 km. Oh no, the EV is no alternative for us.
Max: Well, we used electric heaters in the morning to warm it up.
Cevin: Well, I've also often thrown an electric fan into the car in the morning simply to get it defrosted. If you don't, then you first have to scrape ice off the window outside and then inside (…) in our Danish climate I must say, this test model is not suitable here.
Bella: You just don't want to lower your living standard to what was normal in the fifties, not in terms of driving comfort, otherwise the EV has been very good, but for security purposes (…) you're not willing to sit with a cloth and wipe the glass down like your parents and grandparents.

The above illustrates the fear of neglecting the meaning of comfort (and safety), which again are an outcome of the conventional norms comprised by spatially and temporally dispersed but interrelated practices interconnections and performances.

6.2. Risk of developing (unintended) rebound effects

Rather than reducing the current emissions of carbon, the intervention paradoxically actually increased the present mobility demand by reducing the cycling rates and the use of public transportation, and thus critically reinforce household desires to obtain a second (or third) vehicle, as clarified:

Mia: My husband has also been happy during this period because he could use our own car. I usually take the car, and he takes the train, but in this period of having two cars, I took the EV, and my husband took our own car.
Interviewer: Does this mean that you're now tempted to have an additional car?

Mark: It has been good to have an extra car and to avoid cycling. I've gained five kilos extra weight [ironic] (…) but it has been nice to avoid all the coordination related to only having one car. I've often had to drive to Herlev, where my wife works, to pick her up, which has been avoided.
Mia: We've also used both cars at once. My husband has been happy to avoid commuting by train this winter.

The above conversation illustrates that the intervention generated some unintended negative rebound effects. Instead of enabling a pathway for decarbonisation, the design of the trial critically enlarged households' mobility demand during the test period by reducing sustainable mobility modes such as walking, cycling, and public transport. Furthermore, due to the cold engines, the test drivers also begun to use heaters to warm the EVs. Further, and even more paradoxically, the majority of the participants from the focus groups began to recharge the EVs during the critical peak hour when they came home from work. This significantly indicates the risk for conventional interventions to reinforce the need for private automobility instead of reducing the distance travelled together (Kester, 2018). Correspondingly, several investigations underpin how the massive EV uptake in Norway caused rebound effects (due to the EV's offsets of potential energy savings) and risks to increase the demand for a second or third vehicle. Therefore, interventions as well as policy regulation need to be aware of developing rebound effects, as long as these frameworks neglect challenging the current mobility demand.

In opposition to the second sample (participating without economic benefits), the first sample (offered dynamic pricing schemes) managed to peak-shave. Instead of plugging in their load cable during the critical peak hour when they returned from work (as the second sample did), the combined smart-grid experiments influenced on participants consumption patterns. This underpin how synchronisation of smart-grid experiments is assumed to increase motivation, although the extent of change (and disruptions) in current everyday routines of consumption increase. This further illustrate the complexity, and importance, of designing interventions that make sense in the everyday.

6.3. 'Smart' governance of practices on the policy agenda

The last but most decisive outcome of this analysis is an affirmation of the critical need to put power to govern mobility practices on the policy agenda. Hitherto, practice-based research fail to be specific about how we might change and intervene in the current resource-intensive (mobility) practices. For instance, Shove et al. (2015) underpinned the arrangement of infrastructure as particularly powerful but did not suggest how transformation is acquired. In light of the urgent need for sustainable socio-technical change, it seems appropriate to identify the specific intervention points for transforming the interrelated multiple systemic practices. Instead of giving all practitioners the same (ontological) status of power, the time has come to discuss who, where, when, and how to govern, intervene, and change everyday practices in less resource-intensive directions. Instead of entrusting private companies to provide sustainable transition, this case study underpins how public initiatives of transition require involving broad collaboration between a wide range of different actors (such as mobility operators, city planners, researchers, etc.) in order to facilitate governance processes that generate and anchor long-term workable practice- configured sustainable solutions.

This paper illustrates how the EMO has some obvious rationales and, in opposition to the participants, for example, obviously possesses a significant role in governing practices because of the power to provide charging stations and private equipment in Denmark and abroad. Although innovation, regulation and incentives are fundamental, increased EV adoption will not automatically lead to a decline in sales of combustion cars but may increase the total vehicle population, for instance by increasing the need for a second or third vehicle and/or increasing the peak demand through charging during peak hours.

As already briefly mentioned newly initiated projects (e.g. ENERGISE and SIMS) intend to expand knowledge of users and households' everyday practices in order to provide comprehensive, and more specific knowledge about how to design existing and future interventions to change consumption into

more sufficient ways. This could testify that the dominant approaches slightly recognise the lack of change within the traditional technological approaches, and to some extent recognise the difficulties of changing a system that are built on continuous economic growth and fierce competition between companies and nations. Changing existing resource-intensive practices within the current paradigm is a long-term difficult task, which vitally start by reframing powerful mobility norms and, through collaborative processes among multiple change agents, identifying the crucial practice-based intervention points.

Hence, ambitious EV interventions need to change the powerful notions of freedom, flexibility and comfort by challenging and reframing the current ideas about the 'the good life' as being tightly linked to the freedom. Interventions should instead promote the quality of life as the freedom from time spent on refuelling at petrol stations, freedom from polluting our society and environment, freedom from a bad conscious, freedom from the oil industry and oil-producing countries, freedom to use our own produced renewable energy for free, and perhaps freedom from maintenance by leasing and sharing EVs instead of owning a vehicle. Furthermore, this study demonstrates some benefits related to combining smart-grid interventions. In contrast to the households participating in the combined smart-grid trial, participants (without economic incentives) neglect to postpone charging to the night-time. Recognising the synchronization between more smart-grid trials, the combination of practices, and the collective and natural rhythms, this analysis illustrates that future interventions must be aware of boosting compatibilities before the experimentation phase. In this case, the positive promotion caused high expectations, consequent huge disappointments about the technology performance, why framing and implementing new technology better be concerned by 'the higher you climb, the further you fall'.

7. Conclusion

Based on a qualitative study of Danish household experiences with EV driving, this paper sought to uncover the conflict between the operators' claim that the tested EVs covered the driving needs and that only about 10 out of 1578 participants adopted an EV after three months of test-driving. The dominant explanation among respectively the EMO and participants was that the lack of adoption resulted from the EVs limited driving range, which was anticipated to be resolved by the present innovation in technology. Eight years after the mobility intervention began, after massive research and development investment, the market uptake of EVs in 2019 is still extremely limited. Given the global hype in 2011 (and still today in 2019) about the huge smartgrid potential of EVs, and the persistent nascent uptake worldwide, this study calls for an alternative problem framing that goes beyond the conventional problem framings by recognising the structures of interconnected practices.

Based on Spurling and McMeekin's (2014) three practice-based policy framings of mobility interventions, the analysis shows that the EMO, to some extent, attempted to recraft the elements of driving due to massive promotion of EV's sustainable and economic fortunes and by strongly committing participants to adhere to the project rules within the three months of test-driving. Paradoxically, this analysis shows that, instead of recrafting or substituting resource-intensive combustion driving with electric driving, the EMO actually reproduced, and even more critically, increased mainstream norms around contemporary mobility needs. The lack of ambition to reduce conventional car driving elucidates how the experimentation and trial participation critically enhanced the need for a second vehicle and reduced daily walking and cycling practices.

Corresponding to practice-theoretical scholars' core concerns (see e.g. Nyborg and Røpke, 2011; Shove, 2010; Strengers, 2013), the reallife experimentation inappropriately surged levels of comfort and convenience among the participants. In part, this is due to the demo project's rules and frames (for example, the requirement of owning a vehicle in advance), and lack of ambition to negotiate the current levels of broader automobility demand. This critically underpins that future mobility transition should take care concerning entrusting private companies with the responsibility of reducing carbon emissions. Notably, this paper significantly distinguishes from judging the specific potential of EVs to deliver actual decarbonisation, but nevertheless suggests traditional EV interventions to acknowledge the general

need to change mobility demand, not least regarding the fact that increasing EVs never will solve co-related problems of congestion, traffic jams, or rush hour.

Due to conventional approaches' persistent reproduction of the current mobility demand by taking conventional car driving as the predominant benchmark and ultimate success criterion, future sustainable interventions need to consider how to change the interlocked mobility practices. As a first step, interventions are needed in the infrastructures and institutions, why urgent mobility transition need to identify crucial intervention points in current material arrangements. By illuminating the strong connections of driving practices to other practices, such as working, social care, leisure activities, food-provisioning practices, this research shows how mobility practices (and their combinations) intersect in wider systems of spatial and temporal bundles and complexes of social practices. The analysis empirically illustrates how EV driving and load management are much more than connections between transport and energy systems, why the persistent low EV uptake rather should be explained by the electric engines' incompatibility to perform the contemporary temporal and spatial configurations within the existing system of practices.

Moreover the analysis raises a warning against the dominant assumption about consumers to automatically behave as innovative smart-grid operators. These findings underpin how driving electric, time-shifting and flexible consumption are complex affairs that fundamentally require solutions that are ‘workable’ and operate ‘smartly’ in real-life conditions. Instead of framing EVs competitiveness, future EV interventions need to recognise the spatial and temporal organisation of daily practices and frame the fortunes of integrating EVs in peoples' already time-pressed daily lives. Understanding how driving practices combine, intersect, and overlap with other (domestic) practices is crucial for future mobility interventions to change the level, scale, and character of the current (auto)mobility demand. The potential of EVs will thus first be realised when intervening and changing the infrastructures and institutions within the interlocked system, which presupposes involvement of a wide set of potential change agents that acknowledge the urgent need to change the present unlimited demand for mobility. Hence, interventions pivotally need to clarify whom, where and when activities take place to reconfigure the entire system.

This presupposes identification of the role of powerful discourses to govern practices in order to facilitate processes of broad collaboration among multiple (powerful) actors. Designing new, sustainable mobility solutions for the unknown future should take shape of co-creation. Acknowledging the need to design long-term, effective, interdisciplinary, practice-based, user-friendly, energy-efficient mobility solutions simultaneously need reconfiguration of the current interlocked petrol-based car system. This underpins the final point about the emergent need to reconstruct meaning, which require redefining of the existing norms associated with everyday mobility. Concrete examples gained from this analysis could be to frame meaningfulness according to load management, such as the gain of time/freedom to avoid petrol stations to refuel and the environmental and economic benefits of using electricity produced at home, and/or encourage stakeholders to discuss and reframe (mobility) demand. This puts the ‘negotiability of demand’ and discussions about ‘the good life’ to the front on the political agenda. Today, individuality, flexibility, and freedom construct ‘the good life’, which is why reframing what constitutes the ‘quality of life’ in a less consumption-intensive society seem fundamental.

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