Eras of Electric Vehicles: Electric mobility on the Verge. Focus Attention Scale

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ABSTRACT: Daily or casual passenger vehicles in cities have negative burden on our finite world. Transport sector has been one of the main contributors to air pollution and energy depletion. Providing alternative means of transport is a promising strategy perceived by motor manufacturers and researchers. The paper presents the battery electric vehicles-BEVs bibliography that starts with the early eras of invention up till 2015 outlook. It gives a broad overview of BEV market and its technology in a chronological classification while sheds light on the stakeholders' focus attentions in each stage, the so called, Focus-Attention-Scale-FAS. The attention given in each era is projected and parsed in a scale graph, which varies between micro, meso, and macro-scale. BEV-system is on the verge of experiencing massive growth; however, the system entails a variety of substantial challenges. Observations show the main issues of BEV-system that require more attention followed by the authors' recommendations towards an emerging market.

1 INTRODUCTION

We are witnessing a rapidly urbanizing world with an increasing strain on global resources, regional governances and local services; cities need to be smarter. Commuters by cars whether daily or casual ones are considered to be the main contributors to air pollutants and energy depletion. Enormous trials throughout the years have been conducted to reach viable solutions for the soaring problem. By looking into the transport sector, alternative fuel based means of transport open channels for greener communities. Over the last decades, the focus attention given by motor manufacturers, researchers and all stakeholders, in different regions of the world, has been fluctuating and alternating. Dramatically, this change has remarkably formed the development and deployment of green mobility, which in return builds and creates smart communities and livable environs.

1.1 *Train of thoughts*

This paper presents an overview of the Battery Electric Vehicle-BEV development and its future prospects. The authors are interested in monitoring and scaling the attentions of each era, plotting and parsing them in an analysis graph, and coming up with an analytically collaborated overview of the eras. It starts with an introduction that covers the definition of smart communities the world is aiming at. It goes through the different active regions, which are taking initiatives towards better existences, and ends viewing the most promising green mean of transport, BEVs. The following sections of the paper present the eras of development, discuss the proposed tool, Focus Attention Scale-FAS, and finally view the future prospects and gives recommendations covering the gaps.

1.2 *Smart Communities and the power of transport*

Over the past four decades, the environmental burden of road vehicles has become increasingly important. In response to that, environmental protection and energy conservation are growing concerns worldwide (Chan and Wang, 2004). Many of industrial developed countries are embarking on policies and programs to encourage and promote building new smart communities. The development of these communities means incorporating sustainability and resilience codes which requires integrated solutions that address the key elements of a smart city: energy, urban design, mobility, and lifestyle (Beeton, 2012). A stream of transferred knowledge, strategies, and technologies can be nurtured between regions particularly adopting technologies to local contexts of developing countries and emerging economics (Bongrardt, 2011). Pioneering cities and model regions should be kept evolving over time to accommodate up-to-date regulatory frameworks, technologies and anticipate future requirements (Beeton, 2012).

Transport is a vital spine for societies to deliver logistics solutions and enable mobility. Worldwide and especially across Europe, we have a range of technological opportunities and strategies available for the smart and sustainable transportation modes in the 21^{st} century. Depending on which mode, fuel type, and source we are choosing, in return, this has consequences and benefits for reducing the negative environmental impact of transport modes (Elbanhawy et al, 2012A). In literature, it has been discussed and perceived that Battery Electric Vehicle (BEV) is a promising form of technology pathway for cutting oil use and CO_2 emissions (Outlook, 2012). BEVs offer considerable potential to make progress in a variety of wider environmental, societal and economic objectives (Wee at al, 2011), which accelerates the development of smarter cities. This is due to the importance and the influential effect of transport sector on our finite world. Transport can shift vicinities, suburban, and neighborhoods to greener livable communities. BEV interfaces with different domains in communities and it is intelligently responsive to future green lifestyles (Beeton, 2012). Substantial conservational benefits for environment and energy are to stay away from oil-based fuels and work towards ultra-low carbon, low carbon emissions vehicles (LCEV). LCEV is a part of the whole picture called 'BEV Ecosystem'. BEV Ecosystem as defined by Beeton (2012), is the total system, of infrastructure required to support the operation of BEVs. Intelligent infrastructure, innovative services, frameworks and regulations related to buildings, smart grids, community and economics, and change in consumer behavior are positive transformative phenomena that indicate smarter cities.

The development of LCEVs has taken an accelerated pace over the last decade (Cresta, 2012). It has been pointed out as a solution for: (1) reducing CO_2, and the green house gasses emissions (GHGs), (2) cutting down on the petroleum dependence, especially affecting to the high associated dependence from the exporting countries and the economic markets, (3) optimizing the power system exploitation by flattening the demand curve, (4) integrating renewable energies into distribution system levels, and (5) improving the energy efficiency in the transport sector (EPSH4, 2012). Urgent challenges presented by carbon reduction targets, climate change concerns, air quality goals, and resources depletion threats; most developed economies are conducting low-carbon policies and investing on efficient energy technologies. They are relying heavily on the electrification of road vehicles especially in a single vehicle owner to achieve carbon reduction goals (Morton et al, 2011).

1.3 *Strategic Energy Technology Plan*

BEVs play a crucial role in European plans of CO_2 emissions reduction (Cresta, 2012). Several plans and energy roadmaps have developed likewise 2020 and 2050 to set threshold for the CO_2 and GHG (OLEV, 2011). In 2008, the European Union tackled environmental challenges through distinctive policies. The core idea behind the European Strategic Energy Technology Plan (SET-Plan) is to establish an energy technology policy for Europe. It is a strategic plan to accelerate the development and deployment of cost-effective LC technologies. The plan comprises measures relating to planning, implementation, resources and international cooperation in the field of energy technology in the different economic markets. For 2020, the plan is to reach its 20-20-20 goals of a 20% reduction of CO_2 emissions, a 20% share of energy from low-carbon energy sources and 20% reduction in the use of primary energy whereas by 2050, it aims at reducing EU GHG emissions by 80 - 95%. (European Commission, 2010).

In UK, the UK Low Carbon Transition Plan was presented to Climate Change Act (CCA) in 2008 recognizing the defining issues of the 21st century, which is the low carbon economy. The plan drew the route-map for the UK's transition to 2020 demonstrating the technology to capture carbon dioxide and lock it away which is considered as the UK's first ever comprehensive low carbon transition plan to 2020. This plan will deliver emission cuts of 18% on 2008 levels by 2020 (and over a one third reduction on 1990 levels). Committing to source 10% of UK transport energy from sustainable renewable sources by 2020.

In United State, many environmental acts and amendments have been released since late 20th century having said that the States of America vary in their plans though the same principles and future roadmap-planning bases. Likewise, the Energy Independence and Security Act was amended in 2007 which is aiming at moving the United States toward greater energy independence and security, increasing the production of clean renewable fuels, protecting consumers, increasing the efficiency of products, buildings, and vehicles, promoting research on and deploying GHG capture and storage options, and improving the energy performance of the Federal Government, and for other purposes. In 2010, the Vehicle Technologies Program (VTP), a multi-year program plan was set for (2010-2015), by the office of Energy Efficiency and Renewable Energy U.S. Department of Energy. VTP facilitates environmental responsibility by advancing technologies to reduce passenger and freight emissions. It outlines the scientific research and technology developments for the five-year timeframe that need to be undertaken to help meet the administration's goals for reductions in oil consumption and carbon emissions from the ground transport vehicle sector of the economy. Its goals are to reduce carbon emissions level of 2005 by over 40 percent by 2030 and over 80 percent by 2050 (EIA, 2009).

1.4 *Hybrid Electric Topologies*

The BEV in general can meet the consumer needs and has an added value to move the niche market to a future mainstream one. Though the upfront price and other matters regarding technicalities, the carbon efficiency benefit over the latest internal combustion engines, appearance, capacity and the daily-use remain hindering the market penetration. A mass production can be reached when there are financial incentives for early adopters and a compelling sustainable social and business models for BEV use to allow manufacturers to plan for a long-term market and (The Royal Academy of Engineering, 2010). The environmental burden of using conventional means of transportation and in the presence of the increase of global population and operations compels the world to strive for sustainable road transport. LCEV weather HEV or BEV have distinct advantages and industry technologies are maturing specially to extend the driving range while considering the upfront cost. In 2001, Hong Kong University designed U2001 EV where the first mass produced HEV product was Toyota Prius in 2003. U2001 design incorporated a number of advanced technologies: navigation system and intelligent energy management. This ECarLab was aiming at setting a benchmark for the energy consumption, emissions and drivability, propulsion system, control strategies and storage. It was meant to serve as a platform for more developments and demonstrations and market applications (Chan and Wang, 2004).

The barriers and hurdles facing BEV market can be named. The market entails a variety of substantial challenges (Warth, 2012). The serious challenge to have a successful commercialization summarized in (1) the leverage of upfront cost (Chan and Wang, 2004), (2) the availability of high energy-density batteries at a low price and with a long enough cycle life for BEVs to be economically viable, (3) charging without overwhelming local distribution circuits (The Royal Academy of Engineering, 2010), (4) visual accepted appearance, and (5) performance and usability which include the practicalities of charging vehicles, BEV technology and the integration of efficient charging infrastructure. All these aspects work on meeting the market demand by having a competitive edge and target potential users of developed economics. The market-targeted sector is the initial crucial step for a proper commercialization. BEV market penetration is in direct relation with the level of integration of society strengths (governments, industry, research institutes, policy makers) and society awareness level and willingness to shift products. (Chan and Wang, 2004).

1.5 *Electric vehicles initiate (EVI) countries*

In 2011, BEV pioneering countries representing North America, Asia and Europe, collaborated forming an EV Initiative (EVI) consortium. Each governance/ jurisdiction, cotenant, has a rationale behind going onwards and also has a look-ahead perspective. Asia, the rapid growth of the vehicle market and the increase of road vehicle pollution in Asia's megacities have made electrification of vehicles an important policy and technology goal for many Asian nations. Europe, the climate change worrying concerns, numerous cities and regions across Europe are developing programs and infrastructure to smooth the transition to electric transportation in their cities. The European Union and many national governments are providing incentives and initiatives to make this transition happen in the next decade. And finally, the Untied States has made plug-in electric vehicles centerpieces of national energy policy and the Department of Energy is funding/supporting this effort in a full array of programs (EVcity, 2012). The below graph, figure (1), was plotted in 2011 and it shows the ratio between the conventional VS BEV in EVI countries.

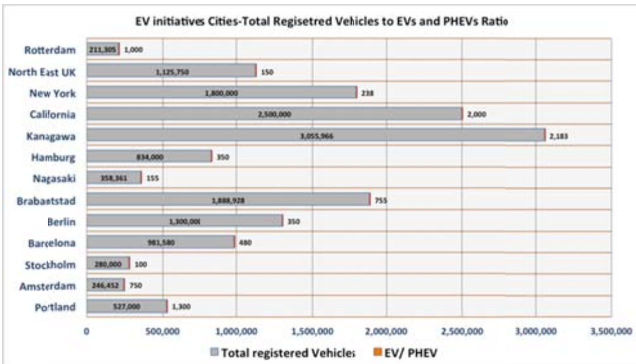

Figure 1. EVI countries number of registered BEV VS conventional ones

2 FOCUS ATTENTION SCALE (FAS)

In this study, international, regional and local calls for environmental protection and resources preservations are the core. Shifting towards LCEV is one of the initiatives and solutions to overcome the critical environmental and ecological situation our world is facing. Especially in more developed countries where the automotive is extensively used. As was discussed above, there are different calls/ focus attentions throughout the decades from which we can depict the big picture. Via observations we can form the shape of BEV system hence project it in analysis graphs. One of the useful projections can be to weigh and scale the focus attention of a BEV industry, initiatives, technology, and frameworks.

First we need to understand the 'Focus Attention Scale-FAS. FAS is an analytical scale that projects the attention that is given by an authority (ies)/repository (ies) to a special product/ industry/ system throughout a definite period of time. For quantification purposes, the achievements and main paradigms of each era have to be weighted in terms of two parameters: influence and magnitude. Hence the FAS is a coupled-scale graph that monitors and examines (1) the influence and (2) the magnitude of an attention. The matters of attention can be grouped into special categories. These categories are editable as the selection and definition of each category depends on the era's main paradigms, which ranges between, but not limited to, environmental concerns, climate change, low carbon international frameworks, moves, and standards…etc. The influence weight reflects the severity of attentions and how effective was the initiates and the moves. The magnitude reflects the range of the attention. Both influence and magnitude form the level of achievements, which at the end reflects the era main paradigms hence the designed scale. This designed tool is an interactive analytical scale, it can be applicable to evaluate and quantify progress, achievements and identify the main paradigms of a system. As later, the deigned scale should be elaborated to reflect and quantify how smart are communities and neighborhoods.

The tool's strength is shown in having this coupled scale (influence + magnitude), which is changeable among time. Considering these two parameters at once should give a clear quantification as for instance the influence might be very high though the magnitude is low which results with a low score at the FAS. However, the proposed tool has pitfall. The evaluation process might be biasd due to the personal judgment and perception of the overall quantification of each era's achievements and moves. This is to be overcome by sitting more vivid performance measures and threshold to quantify syntactic parameters.

This scale works at three different levels/ categories: global (macro-scale), regional (meso-scale), and local (micro-scale). Macro-scale is to think at the globe and anticipate contribution to desirable scenarios. This scale doesn't focus on a particular region or city. It rather concerns with scaling up the bigger picture and looking into the future via worldwide views, moves and acts. Whereas, the micro-scale is to scale down to street level and look into the BEV system(s) individually, examine the infrastructure, user's willingness and preferences, and plan locally for the city or the country. In between, there is the meso scale, which views the BEV system at a regional level. It is mainly concerned with the measurable targets of pioneering regions. In the following part of the paper, an overview of the BEV system is discussed followed by an observed projection of the focus attention of each era in a FAS.

3 ERAS OF BEV

The deployment of LCEV has been through several phases first of which was the golden age of BEV in mid 80's. The below table depicts in a chronological order the main paradigms that each area was known for with regard to LCEV and related issues. The table starts with (1) 1990 the beginning of resurgence time of BEV up till 2012. It is followed by thoughtful discussion about these eras and linking them to the FAS. It worth mentioning that the some of these eras (eras till the turn on the 21st century) were already predefined and documented by analysts and researchers in literature in terms of phrases and spotlights of achievements; whereas, others (eras starting 2000) are defined/ parsed and observed in terms of time frame, most significant raised matters, and consequences by the authors from literature and BEV context. The below table (1) summarizes the main paradigms in points.

Table 1. Stakeholders' attention in a chronological classification (synoptic Overview)

BEV Deployment	Aspects and focus attention matters/ Main Paradigms
First Era (1990-1998)	
The revival of Interest	- Outlook: expected growing population/ vehicles; - International Organization for Standards (ISO) for road vehicles (BEV); - Sustainability Standards; - BEV safety and crash standards and codes in the USA; - First Start of range Anxiety: - Enrichment in BEV and HPEV automotive manufacturing mainly in US market.
Second Era (1999-2004)	
BEV Symposium	- EBV presence has been rather marginal; - Presenting a sensible approach for solving mobility problems in cities; - Quick Charging (Fast Charging) technology; http://www.akerwade.com/history.html - Lunching and commercializing BEV Lithium-ion Batteries; - R&D started within the biggest manufactures of BEV; - Policy makers and researchers tackled the area of 'Societal Integration' of BEV; - The use of simulation and geographical modeling to predict vehicular movement. This type of simulation is advanced where in some cases incorporate agent based modeling approach including (Social force and behavioral patterns); - 3D modeling and representation of urban data and road networks. Developing Virtual City Model (VCM) became more viable.
Third Era (2005-2007)	
BEV the Virtual	- Energy Outlook for 2035 in the US. - Looking in-depth at a different technology related matters of BEV: adoptive energy: de-

	mand response, propulsion, battery health, data centers, and grid health; - The existence of graphical modeling and simulation of LCEV applications. Researchers and policy makers started to utilize simulation technique to analyze and predict future implications. Most of the applications are related to technical issues.
Fourth Era (2008-2009)	
BEV Consensus Environment	- Low Carbon Transition Plan in EU and UK targeting 2020 and 2050; - More installation of fast charging; -BEV standardization concerns started to get more attention worldwide. It has been perceived as a major obstacle in implementing enhanced charging facilities. Common and international agreement on the specifications of the interface and the power source (communication protocol, power and voltage range).
Fifth Era (2010)	
The Beauty of Technology	- Pioneering regions putting energy plans and technology mapping for the pathways 2020 and 2050; - Deployment of Intelligent transport systems (ITS) in the field of road transport and for interfaces with other modes of transport. According to EU Directive 2010/40/EU of 7 July, ITS is: system in which information and communication technologies are applied to road transport, including infrastructure, vehicles, users, and in traffic management or a better, safer and smarter transport. - The use of renewable energy to fill the charging point. - Vehicle to Grid (V2G) concept started to get more common (Expected strong growth from 2015-2020). V2G technology utilizes the stored energy in EV batteries to contribute electricity back to the grid when the grid operators request it. This shall economically help the society to (1) reduce the running cost of BEV, increase efficiency/reliability of the grid, and allow all electric drive vehicles to help on powering our homes and offices in return.
Sixth Era (2011)	
BEV the Realm	- Energy plans for 2030 and 2050 in United States and Europe. - In the UK market: Eight national pilot Plugged-In Places (P-IPs) developing a strategy that reflects the priorities and objectives. - Further charging infrastructure is being installed by other agencies, both within and in areas outside these trial areas. Realizing the Potential of the Los Angeles BEV Market. - Solid steps towards global market by the European Commission: ▪ Market positioning (reviewing safety and crash requirements); ▪ Developing a standard charging interface (interoperability/connectivity); ▪ Infrastructures (proving a leading role in building up of charging points); ▪ Power generation/distribution (Environmental and carbon footprint VS the increase in overall electricity demand). - Zero-emission mobility vision (Infrastructure development /attractive lifestyle).
Seventh Era (2012)	
BEV between Rollout and Collision	- A wide spread of fast charging points across pioneering regions; - Smart charging technology (in-vehicle monitor); - Attention to charging station technical spec.(spots,V2G, regulatory frameworks); - Renewable energy as a supply for the charging points (ex. Wind) - Having first car sharing club for BEV in UK

**The information gathered in this table is, as far as the authors' knowledge and observations, the most significant issues aroused in each era. Information collected from (Zpryme, 2010), OLEV), (Dublin, 2011), (FIA, 2011), Nissan2011, (Quebec, 2012), Mid-Atlantic Grid Interactive Cars Consortium (MAGICC)*

3.1 *BEVs Bibliography*

First, the problem was tackled from a global perspective when the international concerns of negative environmental burden were aroused in many developed countries in 1990. These proactive countries started to spread awareness and provide ideas and future solutions calling for sustainability standards and resilience steps. In 1990, the first sustainability standard was drafted in the UK, Building Research Establishment Environmental Assessment Method (BREAAM) followed by the American one, Leadership for energy and environmental design (LEED) in 1995.

In BEVs history, the 90's were considered to be "The Revival of Interest" or 'The Renaissance" phase of BEVs when the manufactures started to redirect their attention after the "The Decline" phase happened between (1930-1990). BEV first came into existence in the mid-19th century, 1848, which is called by "The golden Age". It enjoyed popularity between the mid-19th century and early 20th century, when electricity was among the preferred methods for automobile propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. During 1980-1930, the BEV witnessed its dead-ages when the ICE rendered this advantage moot and was on the verge with a mass production of cheaper gasoline vehicles, the greater range of gasoline cars, quicker refueling times, and growing petroleum infrastructure. Effectively, ICE led at sometimes to the removal of BEV from important markets such as the United States by the 1930s.

During "The Renaissance", (1990-1998), increased concerns have arisen about the environmental impact of the petroleum-based transportation infrastructure, along with the spectra of peak oil, has led to renewed interest in an electric transportation and infrastructure (Better places, 2011). By 2000, "BEV Symposium", the environmental problems started to be tackled from a regional perspective (Hatton, 2009). Active regions started to work with different perspectives each based on their regional priorities. Transport sector was considered to be on the top of many regions priorities' list to reduce Co2 and GHG emissions. By that time, some regions started to work more on finding alternative clean means of transportation. This era witnessed advances in batteries and power management technology in addition to the worldwide concerns about increasing the oil prices and reducing the green house gas emissions. Towards 2004, the solutions took another direction, which tends to be at a local scale. The pioneering active regions, countries and cities were almost identified and each started to work on finding solutions and providing themes, incentives, and programs to promote LCEV within. Stakeholders and academics started holding LCEV conferences and conducting seminars. R&D tackled the BEV interdisciplinary area of research; in addition to the first application of vehicular simulation modeling.

In 2005, ' BEV the Virtual', R&D in BEV related technologies where the use of simulation modeling incorporating agent based modeling techniques was used to simulate phenomenon related to BEV users' usage. In parallel, future outlook for energy demand and climate change which made the attention at regional level. Starting 2008, " BEV Consensus Environment", more predictions of uptakes with the upcoming years for EV and PHEV by UK department for business (The UK Low Carbon Transition Plan, 2008). The SET plan was developed by EU, which made it more at an international attention scale. In 2009, it was a rich year of BEV (proactive steps), fast charging DC has arisen globally which would allow cars to recharge up to 80 percent of the battery's capacity in just half an hour. This technology is back to 2003, when it was first commercially existed via General Mortors across North America. Yet, it is limited due to the high cost and claims about battery lifetime negative effects. In 2010, " The Beauty of Technology", a massive exposure of batteries and supply chain technologies took place. ICT became commercially viable and applicable with BEV systems while the V2G and smart grid analysis and studies aroused which had its positive impact till now in the BEV intake. To conclude this decade (2000-2010), the emerging opportunity for BEV to revolutionize the transport sector and all related technology, charging infrastructure was really immense. (Brown, 2011). Particularity battery technology and charging types (introducing fast charging) were evolving very rapidly to meet desired energy savings threshold, ranges, and speeds (ICT, 2011).

By 2011, " BEV the Realm", rapid superior development happened. More attention was given to emerging the infrastructure networks so that EV drivers have the confidence to make interregional journeys. It is worth mentioning that years 2010 and 2011 have been reflecting a prominent comprehensive development and enhancement in the BEV worldwide market due to the improvement at a regional scale, which feeds global and local attentions in economics in return.

Finally 2012, is the year of the battle between the high-tech system and the user's adaptability, "BEV Rollout and Collision". The era is witnessing the world embarking on policies and regulations, which promote electric mobility. This era's FAS is at a meso-scale which tends to be more local. It opened the road to bring more attention to user's perspective and see the obstacles that users have and try to work on them (OLEV, 2011). At a regional and local scales, several trails to highlight the potential of having BEV in future and how to have a giant leap towards smart community (Dublin, 2011). In 2012, more technology and a perspective of the overall cycle of network which is the utmost technology rollout whereas, the challenges related to system usability remain hindering the emergence of the system hence the market growth. In another way to present the BEV system related technologies, events and industry spotlights, the below graph, figure (2), represents the plots the occurrence of such milestones in a chronological order.

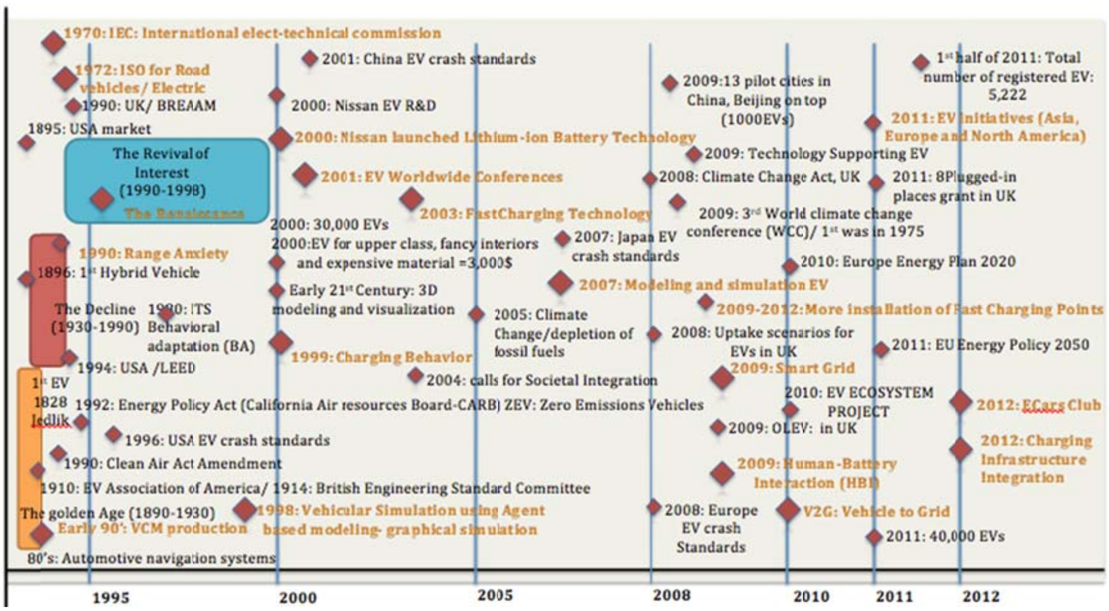

Figure 2. Eras of BEV (Highlights show the main influential related events to up to date BEV-systems)

3.2 *Scaling BEV Eras on FAS*

Most significant events occurred during the period between the mid of the 19th century till 2012 and onwards have been categorized and weighed in the graph. These eight categories are : (1) Frameworks, (2) technology related, (3) Outlook, (4) Modeling and simulation techniques, (5) R&D, (6) manufacturing, (7) Standards and codes, and finally (8) batteries technology. Each category was parsed in the coupled scale (influence and magnitude). The first is the "focus attention strength/influence" scale parameter, which is from 1-5 knowing that at least the attention was given a value of 1 in all eras. The second one is the "focus attention magnitude" parameter; A as global, B as regional and C as micro. In each era, the score has been each summed for 2 scales forming this hypothetical equation: FAS= Influence+ magnitude. For instance, if the resultant is (12-influence) + (A+A+B+B+B+C+B+B-magnitude), then the graph will read this as a meso-scale marginal to be marco with a intermediate influence.

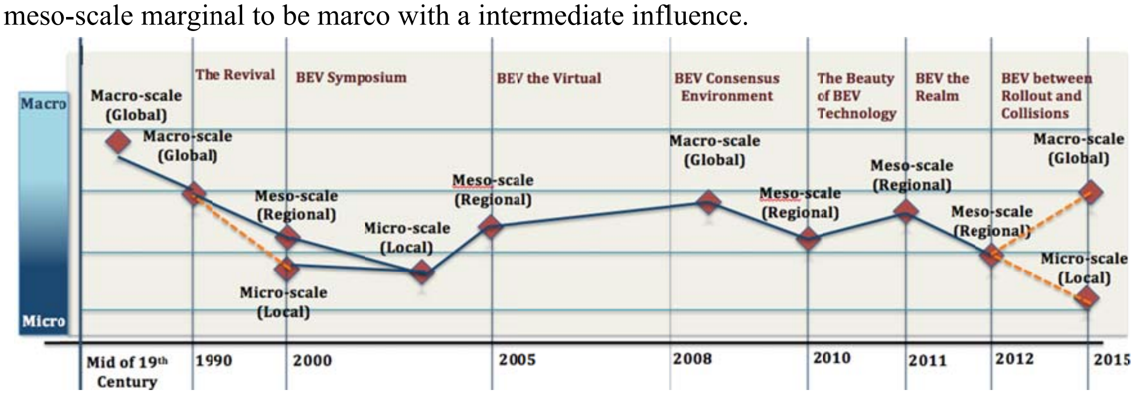

Figure 3. FAS graph

From a closer look into the literature and the overview presented above, observation can be drawn. Three main areas need more attention to support the green mobility for a long-term market: system usability, system standardization and system simulation modeling. These areas and their related matters are considered to be the most influential factors that affect the BEV market penetration from the authors' standpoint. They cover the social aspects of the system and how the users interact with the BEV and how this affects the market penetration and attract potential users (system usability). The second is the merge of the systems in different urban systems of the world to have a unified reliable system at different levels (standardization). And finally the use of highly developed simulation tools to simulate the vehicular movement and predict future implications, which in return assist policy makers and planning authorities. The following lines, discusses each of them in detail.

4.1 *BEV System Usability*

Usability, as defined by ISO 1998, is the extent to which the system can be used by specified users to achieve specified goals with effectives efficiently and satisfaction in a specified context of use. Awareness and accurate understanding of the BEV technology and charging infrastructure system integration, the more likely the system will be rated as being usable and reliable with less propensity to have BA, hence better marketability of BEV; whereas, negative BA indicates poor usability and decreases satisfaction between users. One of the BA syndromes is the BEV range anxiety which is generated from the limited range of a BEV can reach, the daily use of BEVs.

The ability to adapt to new situations in a sense that it benefits group/ individuals is an intrinsic behavioral characteristic, which reflects social, and life intelligence. In driver phycology, there is a terminology named ' behavioral adaption'-BA which refers to the collection of unintended behaviors that arises following a change in the toad traffic system and has a strong effect on crash risk and overall road safety. ITS has high propensity to generate BA. Designers, manufacturers and researchers who are working on the ITS of BEV have to consider intercultural adaptability of potential users/ users. This is likewise any other domain of computer-human interaction; developers should work on creating more usable, acceptable interface to a broader array of user groups be designing adaptive-interface systems. This in turn helps in minimizing the likelihood of negative BA by increasing usability, reliability, users acceptance and marketability (Rudin-brown, 2010).

In BEV context, we can address the system usability via two aspects (1) Range Anxiety and (2) Integration of charging infrastructure. Range anxiety emerged as a concept in the late 1990s and captured a drivers' concern of not reaching their destination while traveling in BEV (Elvire, 2011). It describes consumers' fear that their electric car battery will run out mid-route, poses a major barrier to EV adoption. While EVs such as the Chevrolet Volt, the Nissan Leaf, and Tesla are leading the charge, adoption by consumers will largely be a function of the electric vehicle charging options available. BEV Charging can be domestic or connected to a network whether at destinations or off/ on streets (publically available) charging posts. Studies show that most EV charging currently takes place domestically (Carr 2010). Even so, in order for EVs to gain widespread consumer adoption, it is critical to have an existing integrated charging infrastructure outside homes (Brown, 2010) and (Chan, 2012). These two pillars account for the rigorous planning of daily use of BEV, which reflects the acceptance of BEVs everyday (Cocron, P at al, 2011).

4.2 *Avoiding Obsoleteness and non-Compliance*

Merging EV systems within one country is an intrinsic matter, which remains as an obstacle for a unified worldwide EV market. Merging two clusters served by two different utilities is hardly conceivable. Due to commercial and technical issues, this paramount problem arises which is called standardization. Standardization in BEV market language is the: Official definition of a standard by the international standardization bodies: "a standard is a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context" (Brosschi, 2003). Addressing standardization in electric road vehicles needs parsing the current BEV systems at two levels: (1) Merging between active countries or regions (2) harmonizing the standards level with BEV new technologies.

There are mainly three international standards which are relevant to SDOs (Standards Development Organization) for road vehicles (BEV) are: (1) ISO (International Organization for standards) 1972 and (2) IEC (International Electotechnical Commission) 1969 which jointly formed a regulatory framework in 1996 for road vehicles (BEV) named as ISO SC21-IEC TC 69(Guide, 1996). (3) A more relevant one to automotive is the SAE (Society of Automotive Engineers). ISO, IEC and SAE operate at the international level. There are other national based standards that are also working inline with the international codes like IEEE (Institute of electrical and electronics engineers which is based in the United States, Standardization administration of the people's republic of China, Japanese standardization organization, and European committee for Electotechnical Standardization (Brown, 2011). The merge between local and international standards and prioritizing them in all related matters of BEV manufacturing, technologies, and infrastructure is not an easy target.

In many or every jurisdiction, international standards and country-specific standards exist. These local standards are tending to be relying or consistent with the international ones. However, to stimulate economic growth along the pioneering governments in BEV, which are now placing great emphasis on advancing the development of BEV to meet climate change and energy objectives, requires recognitions of the importance of having compatibility of vehicles operations and consistency across countries. A consistency that ensures that current standards (local or international) are up to these rapidly technological changes worldwide. In other words, the coordination in the developments of the worldwide BEV and its infrastructure protocols and controls across the active regions is essential and required for a unified worldwide BEV trade. Such harmony and generalization level shall ensure public health and environmental protection alongside it shall support the uptake and increase BEV market penetration level.

Standardization is crucial to foster and enable the adoption of BEV and related technologies (Brown, 2011). International and country specific trials have been attempted to standardize BEV and related infrastructure (Brown 2010). At present, several cities and regions in Europe and the North Sea Region are developing strategies and action plans to bring forth electric mobility. One such program is an EU funded project led by the University of Hamburg of Applied Science and has stakeholders and partners (with sub-partners) from Sweden, The Netherlands, UK, Belgium, Denmark, Germany and Norway. The project is called North Sea Region Electric Mobility Network (E-Mobility NSR), and was launched in April 2011. It aims creating favorable conditions to promote e-mobility within the NSR, defining current technological and end-users' barriers, and supporting the market, and assist the common development of e-mobility in the North Sea Region. Translational support structures in the shape of a network and virtual routes are envisaged as part of the project striving towards improving accessibility and the wide use of e-mobility in the North Sea Region countries (NSR, 2011).

4.3 *Graphical Simulation Solutions*

Another gap that needs to be covered is the utilization of computed based representation to simulate the vehicular movement of a specific mode of transport. The use of graphical simulation model has proven successful; however, little research has been conducted in the area of simulating green mobility. Particularly in the area of vehicles movements, the use of computer platforms via modeling and simulation reduces the expense and length of their strategies before starting the prototype construction (Trovao, J et al, 2009). Viewing the BEV system from an end user perspective relates to individual dynamic social behavior types of phenomena, which has lots of independencies, time-delayed occurrence, and interaction and multiple events. This adds more challenge to the development of a simulation model, as it requires regular real-time updates. Analytical solutions and MS Excel package can model simple or even complicated environments events; however, they lack the spatial and virtual representation of models. In addition, MS Excel works more with the optimization problems and successfully provides reliable outcomes, which is different in case of using simulation modeling. In simulation, all feasible solutions are tested randomly and several trials and runs are simulated with spatial representation of the environment. Randomness, time delayed, independencies, system interaction, complexity, spatial interaction, and individual decision rules (social force) are the reasons behind utilizing simulation modeling to solve the present problem (Elbanhawy, 2012).

Vehicle system modeling is conducted over various areas of interest to answer vastly different questions. Traditional areas include modeling for the analysis of vibration, handling, and noise (NVH), modeling of vehicle performance (e.g., acceleration, grade ability, and maximum cruising speed); modeling for the prediction, evaluation, and optimization of fuel economy; modeling for safety, stability, and crash worthiness; modeling of vehicle controls; modeling for structural integrity; modeling to facilitate component testing and validation; modeling for preliminary concept design/ design exploration; modeling for cost and packaging; and modeling for the prediction of emissions (Gao, 2007).

5 DISCUSSION

The importance of looking in-depth at the current BEV-systems and developing these future-oriented outlooks lies in the recognition that growth is by no means certain (Beeton, 2012). This paper facilitates a broad discussion about LCEV and particularity BEV. BEV has been a subject of intense discussion as a key solution to addressing the challenges of increase energy demand, road traffic pollutions over the last decades. Meanwhile, BEV field has a long tradition; however, the system has several challenges and hurdles. The main hinders are those perceived by the user's. The reliability of the BEV and the charging infrastructure remain the main worrying matter for EV divers.

An explicit hierarchy and train of thoughts can portray the overall BEV system in relation with environmental regulatory and proposed solutions mechanisms to overcome theses hurdles. The below figure (4) summarizes the framework proposed by the authors. The carbon emissions concerns were the rational behind occurrence of LCEV hence BEV. Literature showed that most of the focus attention has been giving to the BEV technology related matters, charging calculations and technical analysis. LCEV manufacturing, batteries, and charging infrastructure technology are soaring and evolving rapidly and have been well documented. Yet, researches and databases of BEV-system often involving a range of invested stakeholders do not reflect the real preference and experience of novices. Assessing the potential uptake of alternative means of transport requires an understanding of likely consumer responses (Rowe, 2012). The system usability is a master issue to be addressed via examining human factor principle and ergonomics sciences like Human-Battery interaction (HBI) (Corner, 2010) to eventually cognize the user's perspectives. The social aspect of BEVs, which evolves around the early adopters, is the key element that will lead to mainstream vehicle market (Rowq, 2012), which has a very limited attention in literature.

Another worrying pillar that affects the merge of worldwide market is the standardization. To have a smooth transition to a future, to foster and enable the adoption of BEV system, there should be a wide-range studies, investigations, and researches to ensure that the BEV-system can host the changes in regulatory environments and operating practices. Putting different scenarios and future implications while considering several variables need a simulation platform to run such trials. The aim of this paper was to explore the use of graphical computer simulation as a research tool for presenting the phenomenon. Vehicular simulation has proven successful in presenting different real-time phenomenon.

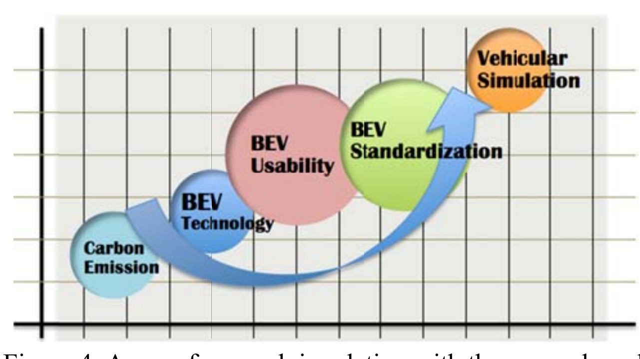

Figure 4. Areas of research in relation with the research problem.

6 CONCLUSION

The paper provides valuable insights on the LCEV global market. BEV and PHEV as clean alternative automotive solutions are important in an imminent short future for being promising forms of technology pathway for cutting oil use and CO_2 emissions. Specific active regions of the world have taken an in depth look at the BEV and its market and they save no efforts to prompt and swiftly shift by small steps towards a giant leap in green mobility market. The paper thoroughly addressed the following issues: (1) stepping stones towards smart communities (2) LCEV aspects, products, technologies, and how/what the stakeholders were interested in through the former eras up till now. The development and deployment of LCEV has been monitored and examined and presented to interpret the attention of each era in the Focus Attention Scale, FAS. It showed the transition between global, regional, and local scales then how it swapped in the meantime to be local, to regional and trying to be global again. As per the FAS graph, firstly, it was at a global scale when many developed countries called for sustainability and environment standards and concepts. Then the attention was moved to a regional scale when active regions and pioneering cities started to prepare the ground for mass deployment of BEV. Eventually, the scale turned out to be at a local level when each country started to focus internally on how it will run these concepts and standards within its boundaries. It is worth mentioning that all levels of FAS are needed to have a successful uptake; however, a smart coherent homogenous integration of the three levels is required. Depends on the BEV-system and market demand, the weigh of each one of them should vary to keep up with the evolving nature of the BEV populations.

And finally, the paper explored (3) the areas that need more attention and gaps that need to be covered in order to support the market and promote green mobility. Analysis showed that system usability, standardization, and the use of graphical simulation representation are the main areas that need more elaboration, attention and development. The observations clarified how effectively working in these areas will support and assist the LCEV market.

From all the above and more, we can now identify the current situation and the next steps to be taken. Cities and metropolitan regions around the world are creating BEV-friendly ecosystems and building the foundation for widespread adoption. To achieve the desired transition to mainstream market acceptance of electric mobility, they must be equipped for two critical challenges: (1) Scaling up to the ‘bigger picture’: how to raise the confidence of BEV users who wish to make longer journeys between regions of the UK, and (potentially) between the UK and other countries via ferry ports, airports and the Channel Tunnel? (2) Scaling down to ‘street level’: how to ensure that EV users, especially those who are less familiar with the locality, have the confidence to find publicly-accessible points, plug-in, and leave their vehicles charging.

A more likely alternative to widespread adoption of pure BEV with their infrastructure requirement would be the plug-in hybrid. It has most of the environmental benefits of BEV without relying on such a comprehensive charging network at multiple destinations. Plug-in hybrids could be adopted quickly as family cars or executive cars, leaving BEV to achieve initial market penetration as second cars, doing low mileage (The Royal Academy of Engineering, 2010). Conventional vehicles will remain the best option for people who regularly drive long distances; and those who purchase BEV for commuting won’t need fast chargers, they can charge overnight at home or during the day at work.

ACKNOWLEDGEMENT

The authors would like to acknowledge the e-mobility NSR-North Sea Region Electric Mobility Partnership (e-mobility NSR) project for funding the PhD research. Project Website htps://e-mbility-ner.eu/. Former publications have been presented and published as conference proceedings, EFEA 2012 and eCAADe 2012 conferences.

REFERENCES

Acha, S., Vandam, K., Keirstead, J., & Shah, N. (2011). Integrated Modelling Of Agent-Based Electric Vehicles into Optimal Power Flow Studies . *21st International Conference on Electricity Distribution Frankfurt, 6-9 June 2011*.

Beeton, D. (2011). *EV ecosystems*. *Update on Annex XVIII: EV Ecosystems Istanbul, Turkey, May 2011*. UK.

Beeton, D. (2012). Electric Vehicle Cities of the Future: A Policy Framework for Electric Vehicle Ecosystems . *EVS26 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium* . Los Angeles, California.

Bongrardt Schmid, D., D. (2011). *Towards Technology Transfer in the Transport Sector*. (T. R. L. GTZ Veolia Transport and UITP, Ed.)Sustainable Urban Transport Project (SUTP). Germany : Transport Policy Advisory Services-GTZ on behalf of Federal Ministry for Economic Coorperation and Development. Retrieved from www.sutp.org

Bosschi, V. Den. (2003). *The electric vehicle: raising the standards*. University of Vrije Brussel.

Brown, S., Pyke, D., & Steenhof, P. (2010). Electric vehicles: The role and importance of standards in an emerging market. Energy Policy, 38(7), 3797–3806. doi:10.1016/j.enpol.2010.02.059

Carr, Housely (2010. *The future of E-Mobility and Commercial Electrifications*, Business Insights

Chan, C; Wong, Y. (2004). *Electric Vehicles Charge Forward*. IEEE power & energy magazine, (December), 24–33.

Chang, Daniel; Erstad, Daniel; Lin, Ellen; Rice, Alicia, F.; Goh, Chia, T.; Snyder, J. (2012). *Financial Viability Of Electric Vehicle Charging Stations*. Los Angeles, California. Retrieved from https://https//luskin.ucla.edu/content/contact-us-4.

Cresta, M., Gatta, F. M., Geri, A., Landolfi, L., Lauria, S., Maccioni, M., Paulucci, M., et al. (2012). PROSPECTIVE INSTALLATION OF EV CHARGING POINTS IN A REAL LV NETWORK : TWO CASE STUDIES, 725–730.

Cocron, P., Bühler, F., Neumann, I., Franke, T., Krems, J. F., Schwalm, M., & Keinath, a. (2011). Methods of evaluating electric vehicles from a user's perspective – the MINI E field trial in Berlin. *IET Intelligent Transport Systems*, *5*(2), 127. doi:10.1049/iet-its.2010.0126

DBT. (1993). *First Large-scale EV charging program in Europe* (p. 1). Retrieved from http://www.dbtus.com

Doucette, R. T., & McCulloch, M. D. (2011). Modeling the prospects of plug-in hybrid electric vehicles to reduce CO2 emissions. *Applied Energy*, *88*(7), 2315–2323. doi:10.1016/j.apenergy.2011.01.045

ElBanhawy, E. Y. ., Dalton, R. ., Thompson, M. E. ., & Kotter, R. (2012). Heuristic Approach for Investigating the Integration of Electric Mobility Charging Infrastructure in Metropolitan Areas: An Agent-based Modelling Simulations. *2nd International Symposium on Environment Friendly Energies and Applications (EFEA)* (pp. 74 – 86). Newcastle Upon Tyne, UK.

ElBanhawy, E. . Y. ., Dalton, R. ., Thompson, E. M. ., & Kotter, R. . (2012). Real-Time E-Mobility Simulation in Metropolitan Area. In H. P. J. H. J. M. Dana (Ed.), *30th eCAADe Conference* (pp. 533–546). Czech Republic, Prague: Technical University in Prague; Faculty of Architecture (Czech Republic).

EIA. *Annual Energy Outlook 2010 Early Release,* 2009

Egbue, O., & Long, S. (2012). *Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions.* Energy Policy, 48, 717–729. doi:10.1016/j.enpol.2012.06.009

European Commission. *Set-plan, towards a low-carbon future*, 2010.

European Union, & Union, E. (2011). ICT for the Fully Electric Vehicle, Research Needs and Challenges Ahead. (S. F. P. European Union, Ed.). DG Information Society and Media Directorate G "Components and Systems" Units G.2 "Microsystems" and G.4 "ICT for Transport."

Ford, A. (1995). ;. XlD *The impacts of large scale use of electric vehicles in southern California*, 22, 207–218.

Ferreira, J. C., & Isel, A. (n.d.). V2*G Smart System: An Intelligent System to the Electric Vehicle Charging Problem.*

Graham-Rowe Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R., Stannard, J., E. (2012). *Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars. Transportation Research*, 46(1), 140–153. doi:10.1016/j.tra.2011.09.008

Nilsson, M., & Park, L. S. (2011). ELVIRA, *Electric Vehicle: The phenomenon of range anxiety* (Vol. 1, p. 16). Sweden: Lindholmen Science Park.

Nunes, R. P., & Coimbra, P.--. (2009). Sim*ulation Model and Road Tests Comparative Results of a Small Urban Electric Vehicle*, 836–841.

Rudin-Brown, C. M. (2010). “*Intelligent” in-vehicle intelligent transport systems: limiting behavioural adaptation through adaptive design*. IET Intelligent Transport Systems, 4(4), 252. doi:10.1049/iet-its.2009.0151

TheUKLowCarbonPlan. (2009). *The UK Low Carbon Five point plan* (p. 228). UK.

Lozano, A. P. (2012). Intelligent Energy Management of Electric Vehicles in Distribution Systems Short Master Thesis in Electric Power Systems and High Voltage Engineering (p. 76). Denmark.

Morton Schuitema, G., Anable, J., C. (2011). *Electric Vehicles: Will Consumers get charged up?* Open University, Milton Keynes, 13.

NSR. (2011). E-Mobility NSR-North Sea Region Electric Mobility Network (E-Mobility NSR) ,. (N. S. R. Programme, Ed.). Germany. Retrieved from http://e-mobility-nsr.eu/

NISSAN. (2011). *Overview of the Electric Vehicle* (pp. 1–38). UK.

OLEV. (2011). *Making the connection- The Plug-In Vehicle Infrastructure Strategy*. United kingdom: Office of Low emissions vehicles (OLEV).

Rodriguez, J. S. (2010). *Smart Grid Insights* : V2G (p. 73). USA. Retrieved from http://www.zigbee.org/Home/SearchResults.aspx?q=smart+grid+insights

Rong, Z. (2011). *Introduction of China electric vehicle standardization work* (p. 34). China. Retrieved from http://www.cse.anl.gov/us-china-workshop-2011/pdfs/Codes and standards/Introduction to EV standardization work in China - Zhou Rong.pdf

Sánchez-martín, P., Sánchez, G., Morales-españa, G., Member, S., Acronyms, A. M., & Evb, E. V. (2012). *Direct Load Control Decision Model for Aggregated EV Charging Points*, 27(3), 1577–1584.

The Royal Academy of Engineering (2010). *Electric Vehicles: charged with potential,*
www.raeng.org.uk

Warth, J., Von der Gracht, H. a., & Darkow, I.-L. (2012). *A dissent-based approach for multi-stakeholder scenario development-The future of electric drive vehicles*. Technological Forecasting and Social Change. doi:10.1016/j.techfore.2012.04.00

Wee, B. V, Maat, K., & De Bont, C. (2012). *Improving Sustainability in Urban Areas*. European Planning Studies, 20(1), 95–110.

WorldEVCities&EcoSystems. (2012). *EV CITY CASEBOOK A LOOK AT THE GLOBAL ELECTRIC VEHICLE MOVEMENT* (p. 75). Retrieved from http://www.worldevcities.org/projects/#