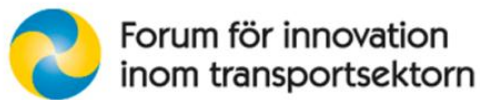


# Governance for electric vehicle innovation

## Lessons from South Korea, India, China and Japan

**Electric and hybrid cars** are a prioritised area in Sweden, as they are in many other countries, as one of the components of a fossil fuel independent vehicle fleet. This report presents a picture of the current status of four central actors on the global playing field in this area: South Korea, India, China and Japan. The aim is to describe the processes that control development in the respective countries and indicate the primary driving forces and the factors that are slowing development down.



The Swedish Agency for Growth Policy Analysis has been commissioned by the Forum for Innovation in the Transport Sector (Forum) to conduct three studies of policies in other countries to find pathways to these solutions. Forum is a network of public and private players in the transport sector in Sweden and its most important objective is to develop common national strategies for research and innovation – strategies that will increase the competitiveness of Swedish enterprise, make transportation more efficient and reduce the sector's environmental impact, for example from carbon dioxide emissions. Read more at <https://transportinnovation.se/>



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## Förord

Transporter av personer och gods utgör blodomloppen i den globala ekonomin och har de senaste årtiondena blivit allt viktigare, smartare och mer effektiva. Baksidan med denna utveckling är den huvudsakligen fossila energianvändningen och de växthusgasutsläpp som transporterna ger upphov till. Farliga partiklar, trängsel och buller är andra problem som dagens transportsystem förknippas med. Hållbara transportlösningar är således en prioriterad fråga, i Sverige liksom runt om i världen.

Tillväxtanalys har fått i uppdrag av Forum för innovation inom transportsektorn (Forum) att genomföra tre studier av politik i andra länder för att hitta vägar till dessa lösningar. De områden som studierna fokuserar på är: Elektrifiering av fordonsflottan (Indien, Japan, Kina och Sydkorea), Snabba och attraktiva tågtransporter (Indien, Japan och Kina) samt Alternativa bränslen (Brasilien och USA). Utgångspunkten för urvalet har varit de länder som Tillväxtanalys bevakar samt områden där det bedömts finnas intressanta lärdomar att dra för och Forum i arbetet med att utveckla den svenska transportpolitiken.

Denna rapport fokuserar på politik för elektrifiering av fordonsflottan i Indien, Japan, Kina och Sydkorea.

En av de observationer som görs i rapporten är att det finns påtagligt många likheter kring utvecklingen av el- och hybridfordon i de olika länderna. Energisäkerhet, framtida exportmöjligheter och att begränsa utsläpp är faktorer som drivit på utvecklingen i samtliga länder. En annan gemensam faktor är regeringarnas roll som pådrivande kraft, i samtliga länder i nära samarbete med den inhemska industrin.

Samtliga länder, möjligen med undantag för Indien, försöker också skapa en inhemsk efterfrågan genom olika former av subventioner – som också syftar till att gynna inhemsk industri.

Hittills har framgångarna dock i stor utsträckning uteblivit. Att batteriteknologin har visat sig svårare att bemästra än förväntat tillsammans med avsaknad av uppbyggd infrastruktur, en ogynnsam prisbild samt bristande tydlighet från regeringens sida vad gäller policy, inklusive standardisering, har varit och är fortfarande hinder på vägen.

Rapporten har författats av Ulf Andreasson (Kina, koordinator), Rajeev Palakshappa (Indien), Izumi Tanaka (Sydkorea) samt Naito Shigeyuki, Helena Tillborg och Niklas Kviselius (Japan)

Martin Flack vid Tillväxtanalys kontor i Stockholm har varit projektledare.

Enrico Deiacco, avdelningschef Innovation och globala mötesplatser

Stockholm, mars 2013



## Table of Content

<b>Sammanfattning</b> .....	<b>7</b>
Drivkrafter, ambitioner och målsättningar .....	7
Styrningsprinciper, aktörer och politik .....	9
Utveckling och framsteg.....	10
Sammanfattande slutsatser om drivkrafter och hinder.....	10
<b>Summary</b> .....	<b>12</b>
Driving forces, ambitions and objectives.....	12
Control principles, actors and policy .....	13
Development and progress.....	15
Summarising conclusions about driving forces and obstacles .....	15
<b>1 South Korea</b> .....	<b>17</b>
1.1 Introduction .....	17
1.1.1 Historical background.....	17
1.1.2 Future and related goals .....	18
1.1.3 Main actors and networks .....	19
1.1.4 Local government.....	21
1.1.5 Private sector .....	21
1.2 Functional pattern of EVs in South Korea .....	22
1.2.1 Development, direction and diffusion of knowledge .....	22
1.2.2 Market formation .....	23
1.2.3 Legitimation.....	25
1.2.4 Resource mobilisation.....	25
1.3 Conclusions.....	26
<b>2 India</b> .....	<b>28</b>
2.1 Introduction .....	28
2.2 Background .....	28
2.2.1 The National Electric Mobility Mission Plan 2020: Moving into Mission Mode to enhance Electric Mobility .....	30
2.3 Building a Collaborative Approach: Main Actors and Networks.....	31
2.3.1 Role of the State in Electric Mobility Development in India .....	31
2.3.2 The important Role of non-Government Actors, Networks and Industry Players .....	33
2.4 Functional Pattern of Electric Mobility in India.....	33
2.4.1 Development, direction and diffusion of knowledge .....	34
2.4.2 Entrepreneurial experimentation: pockets of activity, but momentum of effort is needed for greater uptake.....	36
2.4.3 Market Formation.....	37
2.4.4 Legitimation and Resource Mobilisation.....	40
2.5 Conclusions.....	41
<b>3 China</b> .....	<b>42</b>
3.1 Introduction .....	42
3.1.1 Historical background.....	43
3.1.2 Future targets and related goals .....	43
3.1.3 Main actors and networks .....	44
3.2 Functional pattern of HEVs in China .....	46
3.2.1 Development, direction and diffusion of knowledge .....	46
3.2.2 10 cities, 1,000 vehicles .....	47
3.2.3 Entrepreneurial experimentation .....	48
3.2.4 Market formation .....	49
3.2.5 Legitimation.....	50
3.2.6 Resources.....	52
3.3 Conclusions.....	53
<b>4 Japan</b> .....	<b>56</b>
4.1 Introduction .....	56
4.1.1 Background.....	56
4.1.2 Future targets and related goals .....	57
4.1.3 Main actors, networks and institutions .....	58
4.2 Functional pattern of an electrified vehicle fleet in Japan .....	61

4.2.1	Knowledge development and diffusion.....	61
4.2.2	Influence on the direction of search .....	63
4.2.3	Entrepreneurial experimentation .....	64
4.2.4	Market formation .....	66
4.2.5	Legitimation and resource mobilization .....	68
4.3	Conclusion .....	69

## Sammanfattning

El- och hybridbilar är ett tydligt prioriterat område i Sverige, liksom i många andra länder, som en del av vägen mot en fossiloberoende fordonsflotta. Den här rapporten presenterar en nulägesbild av fyra centrala aktörer på den globala spelplanen inom detta område: Kina, Japan, Indien och Sydkorea. Syftet är att beskriva de processer, politiska och andra, som styr utvecklingen i respektive land och att peka på de primära drivkrafterna liksom de faktorer som bromsar. Utgångspunkten är innovationssystemet kring el- och hybridbilar och de styrningsprinciper som påverkar uppkomst, introduktion och spridning av ny teknik.

I detta kapitel sammanfattas huvuddragen av dessa strukturer i respektive land samt de slutsatser som dras i rapporten.

### Drivkrafter, ambitioner och målsättningar

I samtliga studerade länder har utvecklingen av el- och hybridfordon drivits av en ökat behov av energisäkerhet (framförallt minska oljeimport) och förhoppningar för den inhemska bilindustrin på en kommande kraftigt ökad global efterfrågan på sådana fordon. En ytterligare förekommande anledning, vars tyngd förefaller variera mellan länder och över tid, är dessa fordons betydelse för en förbättrad miljö; för såväl den akuta föroreningssituationen i de asiatiska megastäderna men även för globala klimatförändringar. Som framgår av målsättningarna innebär det att de studerade länderna har målsättningar för att producera el- och hybridfordonen liksom för att ha en betydande andel av den nationella fordonsflottan bestående av sådana fordon.

Table 0-1 Nationella målsättningar för el- och hybridbilar

Land	Drivkraft	Målsättning
Kina	Energisäkerhet Exportpotential för inhemska bilindustrin. Ingår som en av sju strategiska sektorer för Kinas ekonomi Dämpa luftföroreningar i städerna	500 000 år 2015 5 miljoner år 2020 Produktionskapacitet på 2 miljoner fordon år 2020 Bidra till att sänka medelbensinkonsumtionen på den kinesiska bilflottan från nuvarande 0,77 l/mil till 0,5 år 2020 400 000 laddningsstolpar år 2015
Indien	Stödja inhemska bilindustri Energisäkerhet Motverka klimatförändringar	6-7 miljoner elfordon, mest tvåhjuliga, år 2020 År 2020 ska Indien vara en ledande global aktör på området

Land	Drivkraft	Målsättning
Sydkorea	<p>El och hybridbilar utgör en viktig del av landets planer för en grön strukturomvandling</p> <p>Stärka landets bilindustri</p> <p>Höga internationella oljepriser</p>	<p>Sänka landets koldioxidutsläpp med 1,2 miljoner ton år 2020.</p> <p>EV i inhemsk småbilsförsäljning år 2015; 12 procent (ackumulerat 85 000 fordon) och 22 procent år 2020</p> <p>Bli världens fjärde starkaste EV nation år 2017. Tio procent av global marknad år 2020</p>
Japan	<p>Framtida ekonomisk utveckling starkt kopplat till el- och hybridbilar</p> <p>Försöka dämpa den ökade efterfrågan på olja som skedde efter tsunamin 2011</p> <p>Minskade utsläpp</p>	<p>EV och PHEV 2020: 15-20 procent, 2030: 20-30 procent.</p> <p>År 2020 ska man även ha installerat två miljoner laddare och 5 000 snabbbladdare</p> <p>Dessutom åtskilliga teknikutvecklingsmål, exempelvis högteknologiska magneter utan användning av sällsynta jordartsmetaller</p>

Värt att nämna är den skiftande benämning som finns i de olika länderna. Medan man i Kina talar om "new energy vehicles", är det mest använda begreppet i Japan "next generation vehicles" och i Sydkorea "green cars". I Indien har begreppet xEV kommit att brukas. Det ska påpekas att dessa begrepp också omfattar olika teknologier i de olika länderna men där en kärna utgörs av BEV och PHEV. I tabellen nedan sammanfattas de olika begrepp som används i rapporten.

Table 0-2 Definitioner av miljöbilar som används i rapporten

<b>HEV</b>	El-hybridfordon
<b>PHEV</b>	Plug-in elhybridfordon
<b>BEV (ibland EV)</b>	"Rena" batterifordon
<b>FCV (ibland FCEL)</b>	Bränslecellsfordon
<b>ICE</b>	<i>Internal Combustion Engine</i> (fordon med bensinmotor)
<b>CDV</b>	<i>Clean Diesel Vehicles</i> (energieffektiva dieselfordon)
<b>Next generation vehicles</b>	Det uttryck som används i Japan och avser HEV, BEV/PHEV, FCV och CDV
<b>Green cars</b>	Det uttryck som används i Sydkorea och avser BEV, PHEV, FCV och CDV
<b>New energy vehicles</b>	Det uttryck som används i Kina för att fånga alternativ till bensindrivna fordon. Omfattar fem olika kategorier men huvudsakligen avses BEV och PHEV.
<b>xEV</b>	Det uttryck som används i Indien och avser HEV, BEV samt PHEV. Med xEV avses inte enbart fyrhjuliga fordon utan även tre- och tvåhjuliga.



## Styrningsprinciper, aktörer och politik

I samtliga länder har centralmakten haft en viktig roll som pådrivare av utvecklingen, från FoU till implementering och infrastrukturuppbyggnad. Som stöd för utvecklingen har nationella planer tagits fram med uppsatta målsättningar. I samtliga länder har utvecklingen skett i nära samarbete med nationella industriaktörer, framförallt de viktigaste biltillverkarna. (För Sydkorea är det i skrivande stund fortfarande oklart i vilken utsträckning den nyligen tillträdde presidenten kommer att prioritera el- och hybridbilar).

Det kan generellt anas en bristande tydlighet från regeringarnas sida vad gäller policy, inklusive standardisering. En anledning är att man avvaktar teknikutveckling och vill inte ”välja” en viss teknologi för tidigt av rädsla för att vara fastlåst i ”fel” teknologi. I Japan har regeringen hittills intagit en helt teknikneutral attityd i frågan (vilket inkluderar även CDV och ”minifordon”). Det finns också en viss skepsis i Japan mot standardisering då man fruktar att det kan leda till kopiering av huvudsakligen andra asiatiska företag. Teknikneutralitet gäller i princip även för Indien, men här finns det dock en viss antydning till prioriteringsordning utifrån konsumenternas efterfrågan, som förväntas bli utifrån ordningen HEVs, PHEVs och BEVs. Statliga subventioner i Indien är dock störst för BEVs då de fordonen är mest bränslebesparande. I Kina är det långsiktiga föredragna teknologin BEVs men PHEVs ska fungera som en transformationsteknologi. (Även här är dock de statliga subventionerna högre för BEVs.) Samtidigt har man i Kina heller inte stängt dörren för FCV eller annan teknologi som det pågår viss FoU kring. I Sydkorea har BEVs varit prioriterat men den nya presidentens eventuella teknikpreferenser har som sagt ännu inte presenterats. Det är dock troligt att HEVs kommer att lyftas ur ”miljöbilspportföljen” då teknologin uppfattas som tillräckligt mogen för att kunna klara sig på egna ben i Sydkorea. Sammantaget har denna avvaktan i policyutveckling inklusive standardisering lett till ökade osäkerheter och avvaktan från potentiella köpare av el- och hybridfordon, liksom inom industrin där stabila spelregler är en ständigt återkommande ”beställning” till regeringen i de olika länderna.

Vad gäller konkreta insatser för ökad efterfrågan på el- och hybridbilar finns det en bred uppsättning exempel från dessa länder, förutom från Indien där man fortfarande är i en alltför tidig fas och eventuella subventioner ännu inte utkristalliserats.

I Japan kan företag, organisationer och individer få skatteundantag och lättnader vid inköp av ”gröna” fordon. Storleken på dessa skiftar mellan olika typer av fordon. Man kan också få direkta subventioner för inköp och uppbyggnad av laddningsapparat.

Den Sydkoreanska modellen bygger i dagsläget på subventioner för offentliga fordon (bussar) medan subventioner för personbilar fortfarande diskuteras. Vid sidan av detta kan tilläggas bättre möjligheter till parkering (dessutom billigare) och rabatt på vägtullar för el- och hybridfordon. (För Sydkoreas del har man också satt upp legalt bindande miljörelaterade målsättningar för bilindustrin att antingen uppnå vissa uppsatta målsättningar för bränsleeffektivitet eller växthusgasutsläpp).

I Kina testas i ett antal pilotstäder många olika incitament, liksom teknologier, för att introducera s.k. ny energi-fordon. Till några av städerna ger centralregeringen subventioner för inköp av offentliga fordon, främst bussar och taxibilar. I andra fall går subventionerna istället direkt till privatkonsumenter. Utöver de statliga stöden (oklart om det gäller samtliga städer) bidrar de lokala regeringarna med extra ekonomisk stöttning – oftast lika stor som det statliga bidraget. Dessa riktade stöd kompletteras även sedan några år tillbaka med fordonsskatter och andra skatter som kraftigt gynnar ny energi-fordon medan de är stigande med ökande motorstorlek för traditionella bensinfordon. Under senare tid har man i några av de kinesiska megastäderna genomfört pilotprojekt som går ut på att låta personer

som köper el- och hybridfordon kringgå de begränsningar som införts för bilinköp i samma städer. Exempelvis behöver man i Peking inte delta i det månatliga lotteriet för registreringsskyltar och i Shanghai behöver man inte vara med i den månatliga auktioneringen av registreringsskyltar (som i dagsläget har ett pris på ca 75-80 000 SEK).

Gemensamt för samtliga länder är att subventioner har som målsättning att gynna främst eller enbart den inhemska bilindustrin med sammanhörande kluster.

På utbudssidan kan konstateras att de studerade länderna inriktar forskningen på en bred palett av frågeställningar kring industrialisering och implementering av el- och hybridfordon. Man kan dock se en tyngdpunkt kring batteriutveckling och infrastruktur. Forskningsprojekten utförs påfallande ofta i direkta samarbeten mellan stat, inhemsk bilindustri och nationella forskningsinstitutioner.

Statens främsta roll i sammanhanget är att finansiera forskningen. I Kina har staten dock åtagit sig en mycket större roll och påverkar mycket mer direkt riktning och djup på kunskapsutvecklingen.

## Utveckling och framsteg

De studerade länderna har hittills haft svårt att nå uppsatta mål, alternativt är alltför tidigt i processen (särskilt Indien) för att en tydlig bild om framtida måluppfyllelse ska kunna presenteras. Undantagen från detta är HEV-fordon (vid sidan av PHEV) i Japan och i viss mån Sydkorea där massproduktionen tagit verklig fart.

Man kan påstå att regeringarnas förhoppningar har visat sig överentusiastiska och i viss mån naiva kring utmaningarna inte bara kring tekniken i sig utan också möjligheterna att planera denna sektors utveckling generellt. De största hindren är att teknologin, särskilt kring batteriet, har visat sig svårare att bemästra än förväntat, samt avsaknad av uppbyggd infrastruktur och en ogynnsam prisbild. En annan återhållande faktor är bristande tydlighet från regeringens sida vad gäller policy, inklusive standardisering, vilket försätter industriaktörer och även potentiella kunder i en avvaktande position.

Sammantaget har detta lett till låg efterfrågan generellt, och i synnerhet från privatkonsumenter som möter drastiska prisskillnader på miljöfordon och konventionella fordon. Till och med i Kina och Sydkorea, där offentliga aktörer ålagts att köpa el- och hybridfordon och på så vis skapa en initial efterfrågan, är intresset även från dessa aktörer återhållsamt.

## Sammanfattande slutsatser om drivkrafter och hinder

Det finns, trots vissa skillnader, påtagligt många likheter kring utvecklingen av el- och hybridfordon i de olika länderna. Energisäkerhet, framtida exportmöjligheter och att begränsa utsläpp är faktorer som drivit på utvecklingen i samtliga länder. En annan gemensam faktor är regeringarnas roll som pådrivande kraft, i samtliga länder gemensamt med den inhemska industrin. Även de nationella forskningsinstituterna och universiteterna fyller en viktig funktion.

Samtliga länder, möjligen med undantag för Indien, försöker också skapa en inhemsk efterfrågan genom olika former av subventioner – som också syftar till att gynna inhemsk industri – samt andra policies.

Hittills har framgångarna dock i stor utsträckning uteblivit. Att batteriteknologin har visat sig svårare att bemästra än förväntat tillsammans med avsaknad av uppbyggd infrastruktur, en ogynnsam prisbild samt bristande tydlighet från regeringens sida vad gäller policy, inklusive standardisering, har varit och är fortfarande hinder på vägen.

Det som tydligast särskiljer länderna från varandra är hur långt de har kommit i utvecklingen. Japan framstår som det land som otvetydigt kommit längst av de studerade. Sannolikt är detta sant även i ett globalt perspektiv. Därpå följer Sydkorea, Kina och Indien – i nämnd ordning. Där Sydkorea redan har uppnått en viss industrialiseringsgrad kring el- och hybridfordon, Kina är i begrepp att gå från enstaka prototyper till att påbörja massstillverkning och Indien fortfarande är i en begynnande fas där regeringen utarbetar planer och strategier. Det som framförallt verkar ha skapat skillnaderna i hur långt de olika länderna nått inom el- och hybridfordon är kombinationen av allmän utvecklingsnivå, statens övergripande planerings- och implementeringsförmåga samt den inhemska bilindustrins mognadsgrad.

## Summary

Electric and hybrid cars are a clearly prioritised area in Sweden, as they are in many other countries, as one of the components of a fossil fuel independent vehicle fleet. This report presents a picture of the current status of four central actors on the global playing field in this area: China, Japan, India and South Korea. The aim is to describe the processes, political and otherwise, that control development in the respective countries and indicate the primary driving forces and the factors that are slowing development down. The starting point is the innovation system surrounding electric and hybrid cars and the governance structures that influence the emergence, introduction and diffusion of new technology.

This section summarises the main features of these structures in the respective countries and the conclusions that are drawn in the report.

### Driving forces, ambitions and objectives

In all the countries studied, development of electric and hybrid vehicles has been driven by a greater need for energy security (first and foremost reduce oil imports) and hopes on the part of the domestic car industry for a massive global upswing in the demand for such vehicles. Another reason, whose importance seems to vary between countries and over time, is these vehicles' significance for a better environment; both as regards the acute pollution situation in Asian mega-cities and also as regards global climate change. As can be seen from the objectives, this means that the countries studied have objectives to produce electric and hybrid vehicles and to have a national vehicle fleet consisting to a considerable extent of such vehicles.

Table 0-1 National objectives for electric and hybrid cars

Country	Driving force	Objective
China	Energy security	500,000 by 2015
	Export potential of domestic car industry	5 million by 2020
	One of seven strategic sectors for China's economy	Production capacity of 2 million vehicles by 2020
	Reduce air pollution in towns and cities	Contribute to reduce average fuel consumption by China's vehicle fleet from current 0.77 l/10 km to 0.5 l by 2020 400,000 charging points by 2015
India	Support domestic car industry	6-7 million electric vehicles, mostly two-wheeled, by 2020
	Energy security	
	Counteract climate change	India is to be a major global actor in the area by 2020

Country	Driving force	Objective
South Korea	<p>Electric and hybrid cars are an important component in the country's plans for a green structural transformation</p> <p>Strengthen the domestic car industry</p> <p>High international oil prices</p>	<p>Reduce CO2 emissions by 1.2 million tonnes by 2020</p> <p>EVs as proportion of domestic sales of small cars: 12% by 2015 (accumulated 85,000 vehicles) and 22% by 2020</p> <p>Be the world's fourth strongest EV nation by 2017 10% of the global market by 2020</p>
Japan	<p>Future economic development strongly linked to electric and hybrid cars</p> <p>Try to slow the increasing demand for oil that occurred after the 2011 tsunami</p> <p>Reduced emissions</p>	<p>EV/PHEVs by 2020: 15-20%, 2030: 20-30%.</p> <p>2 million chargers and 5,000 quick chargers are also to have been installed by 2020</p> <p>Various targets for technological development, e.g. high-tech magnets without rare-earth metals</p>

The varying terminology used in the different countries is also worth mentioning. While people in China say "new energy vehicles", the most common term in Japan is "next generation vehicles" and in South Korea "green cars". In India, the term xEV is used. It should be pointed out that these terms also include different technologies in the different countries but where BEV and PHEV are the main types. The table below summarises the different terms used in the report.

Table 0-2 Definitions of eco-cars used in the report

<b>HEV</b>	Electric hybrid vehicle
<b>PHEV</b>	Plug-in electric hybrid vehicle
<b>BEV (sometimes EV)</b>	Battery electric vehicle
<b>FCV (sometimes FCEL)</b>	Fuel cell vehicle
<b>ICE</b>	<i>Internal Combustion Engine</i> (cars with petrol engines)
<b>CDV</b>	<i>Clean Diesel Vehicles</i> (energy-efficient diesel vehicles)
<b>Next generation vehicle</b>	The term used in Japan to refer to HEV, BEV/PHEV, FCV and CDV
<b>Green car</b>	The term used in South Korea to refer to BEV, PHEV, FCV and CDV
<b>New energy vehicle</b>	The term used in China to capture alternatives to petrol-fuelled vehicles Comprises five different categories but refers mainly to BEV and PHEV
<b>xEV</b>	The term used in India to refer to HEV, BEV and PHEV. xEV refers not only to four-wheeled vehicles but also three- and two-wheelers.

## Control principles, actors and policy

The government has played an important role in all the countries as a driver of development, from R&D to implementation and infrastructure construction, and national plans with stated objectives have been drawn up to support development. Development has also taken place in all the countries in close collaboration with national industrial actors, pri-

marily the major car manufacturers. (At the time of writing it is still unclear how far the new South Korean president will prioritise electric and hybrid cars.)

A general lack of clarity can be discerned on the part of the governments as regards policy, including standardisation. One reason for this is that they are waiting to see how technology develops and they do not want to “choose” a particular technology too early for fear of being stuck with the “wrong” technology. The Japanese government has hitherto maintained a technology-neutral attitude towards the issue (which also includes CDVs and “mini-vehicles”). There is also a degree of scepticism in Japan as regards standardisation since it is feared that it may lead to copying, primarily by other Asian companies. Technological neutrality also applies in principle to India, but here we find a hint of priority order on the basis of consumer demand, which is expected to be for HEVs, PHEVs and BEVs and in that order. State subsidies in India, however, are highest for BEVs since these vehicles are most economical on fuel. In China, the preferred long-term technology is BEVs, while PHEVs act as a transformation technology. (Here again, state subsidies are higher for BEVs.) At the same time, China has not closed the door on FCV or other technologies currently at the R&D stage. In South Korea, BEVs have been prioritised but the new president’s possible technological preferences are, as stated earlier, as yet unknown but it is probable that HEVs will be lifted out of the “eco-car portfolio” since the technology is perceived as insufficiently mature to be able to survive on its own merits in South Korea. In all, this waiting to see as regards policy development, including standardisation, has led to greater uncertainty and potential buyers of electric and hybrid vehicles also waiting, as is industry where stable rules of play are a recurring “order” from the governments of the different countries.

As regards concrete measures to increase demand for electric and hybrid cars the countries show a wide range, with the exception of India which is still at too early a stage and any subsidies have yet to appear.

In Japan companies, organisations and individuals can be granted different levels of tax exemption and relief when they buy “green” vehicles depending on the type they choose. It is also possible to receive direct subsidies to purchase and install charging devices.

The South Korean model is currently based on subsidies for public vehicles (buses) while subsidies for passenger cars are still being discussed. Other measures include better (and cheaper) parking possibilities and lower road tolls for electric and hybrid vehicles. (In South Korea, legally binding environment-related objectives have been set for the car industry to either achieve certain fuel efficiency or greenhouse gas emission objectives.

In China, a variety of incentives and technologies to introduce so-called new energy vehicles are being tested in a number of pilot cities. In some cities the central government subsidises purchases of public vehicles, primarily buses and taxis. In other cases the subsidies go direct to private consumers. In addition to the state subsidies (it is unclear whether this applies to all cities) the local governments contribute extra financial support – often of the same magnitude as that provided by the state. These forms of direct support have also been complemented for some years by road and other taxes that strongly favour new energy vehicles while they increase with increasing engine size for traditional petrol-fuelled vehicles. In some of China’s mega-cities pilot projects have been conducted where people who buy electric and hybrid vehicles are allowed to avoid the restrictions that have been introduced for car purchases in those cities. For example, in Peking people do not need to take part in the monthly licence plate lotteries and in Shanghai they do not need to take part in the monthly auctions for licence plates (which currently cost between SEK 70,000 and 80,000).

Common to all the countries is that the objective of the subsidies is to primarily or exclusively favour the domestic car industry with its associated clusters.

On the supply side, the countries studied focus research on a broad palette of issues related to industrialisation and implementation of electric and hybrid vehicles with an emphasis on battery development and infrastructure. The research projects are conducted strikingly often in direct collaboration between the state, the domestic car industry and national research institutes.

The primary role of the state in this context is to fund the research. In China, the state has however taken on a greater role and has much more direct influence on the direction and depth of knowledge development.

### **Development and progress**

The countries studied have hitherto found it difficult to attain the goals set or the process is at far too early a stage (especially in India) for a clear picture of future goal attainment to be presented. Exceptions from this are HEV vehicles (alongside PHEVs) in Japan and to a certain extent South Korea, where mass production is well under way.

It can be said that the governments' hopes have proven to be over-enthusiastic and to a certain degree naive as regards the challenges, not only concerning the technology in itself but also the possibilities to plan the sector's development in general. The biggest obstacles are that the technology, especially in respect of the battery, has proven to be more difficult to overcome than expected, the lack of infrastructure expansion and unfavourable prices. Another restricting factor is a lack of clarity on the part of the government as regards policy, including standardisation, which forces industrial actors and also potential customers to adopt a wait-and-see attitude.

In all, this has led to low demand in general and in particular from private consumers who meet drastic price differences between eco-vehicles and conventional vehicles. Even in China and South Korea, where public actors are obliged to purchase electric and hybrid vehicles and thus create an initial demand, interest on the part of these actors is restrained.

### **Summarising conclusions about driving forces and obstacles**

Despite certain differences, there are a great many similarities as regards the development of electric and hybrid vehicles in the different countries. Energy security, future export opportunities and limiting emissions are factors that have driven development in all the countries. Another common factor is the governments' role as a driving force, jointly with domestic industry. The national research institutes and universities also fill an important function.

All the countries, with the possible exception of India, are also trying to create a domestic demand by means of various forms of subsidies – which are also designed to favour domestic industry – and other policies.

So far, however, success has not been forthcoming. The fact that the battery technology has proven to be more difficult to master than expected, alongside a lack of infrastructure expansion, unfavourable prices and a lack of clarity on the part of the government as regards policy, including standardisation, have been and continue to be obstacles to progress.

What separates the countries most distinctly from each other is how far they have come with development. Japan stands out as the country that has undeniably advanced furthest. This is probably also true in a global context. Then follow South Korea, China and India –

in that order. Where South Korea has already attained a degree of industrialisation regarding electric and hybrid vehicles, China is poised to shift from having a few prototypes to beginning mass production and India is still at an early stage where the government is drawing up plans and strategies. The factors that above all else seem to have created the differences in how far the countries have come in the area of electric and hybrid vehicles is the combination of general level of development, the state's overarching ability to plan and implement and the domestic car industry's degree of maturity.



# 1 South Korea

## 1.1 Introduction

### 1.1.1 Historical background

Korea's efforts to support EV development originate in the establishment of the "Law for Development and Deployment of Environment-friendly Vehicles" in 2004. This Law gives a legal basis for the succeeding policies regarding environmentally-friendly / green vehicles and states that the policy is to be reviewed every five years. The effort gained momentum with the introduction of Green Growth by President Lee Myung-bak in 2008.

Green growth has been a central issue for the President Lee's administration since his inauguration in 2008. In the "Low Carbon Green Growth", policy reduction of greenhouse gas emissions is one of the important aspects stated and the transportation sector is no exception. The Presidential Commission on Green Growth (PCGG) has set the target for CO<sub>2</sub> emissions in 2020 at 569 million tonnes, compared to 813 million tons by 2020 business-as-usual. The government has a goal for the transportation sector to account for 17% of the entire domestic emissions by 2015. Reduction of greenhouse gas emissions by greening of the fleet and nurturing of domestic industry are two important driving forces for the Korean government to promote EV. Additionally, high fuel prices were initially a driver for the development.

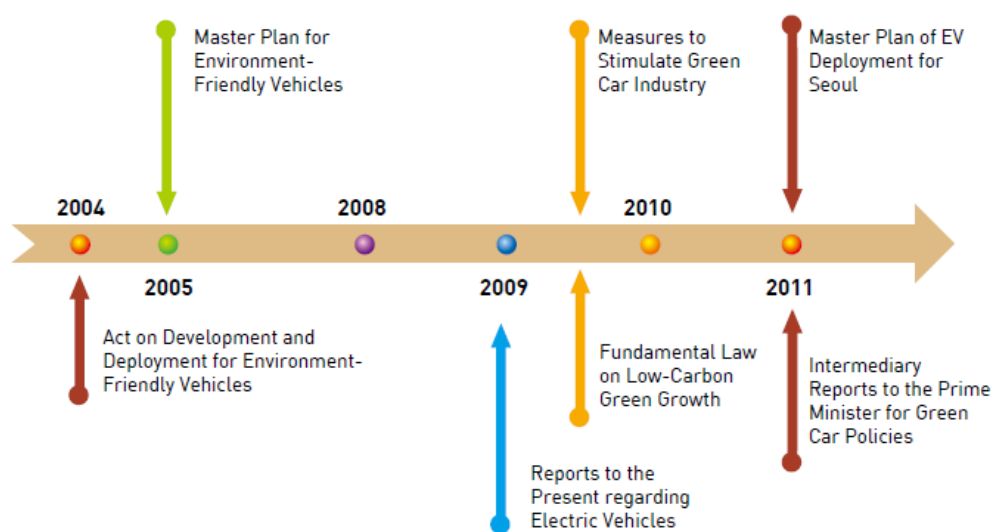


Figure 1-1 Chronological development of green car policies in Korea

Source: Hwang, 2012<sup>1</sup>

However, EV deployment has not advanced as initially planned by the government in 2010 and policy is being reviewed at the time of press. Moreover, the new president, Park Geun-hye, was inaugurated in February 2013. In Korea, the president has a very strong leadership and his/her opinion greatly influences policy. The fate of EV/green car policies is

<sup>1</sup> Hwang, S. K. (2012). *Electric Vehicle in Operation. i Lessons from Transition in Urban Transport Policy* (ss. 142-160). Korean Transport Institute.

therefore not expected to be not clarified until President Park is well-situated in the Blue House.

KIA began producing small-size vehicles in 2012, with 2,000 vehicles delivered to the public sector. 129 companies collaborated to develop EVs with 100% domestic parts. Mid-sized vehicle will be produced in 2013, with 500 vehicles to be delivered to the public sector and 6,000 to private consumers. Two different, legally binding environmental targets are set for car manufacturers for 2015: fuel efficiency and greenhouse gas emission. The companies have the option to achieve either one.

### 1.1.2 Future and related goals

#### *Green Car Roadmap and Strategy for Developing Green Car Industry*

A roadmap indicating the target for green cars was discussed by the advisory board appointed by the Ministry of Knowledge Economy called Green Car Forum in 2010. “Green Car” includes EV, PHEV, FCEL and clean diesel. Based on the discussions in the Green Car Forum, the government announced the Green Car Roadmap in December 2010, stating its vision to become the world’s 4<sup>th</sup> strongest EV nation by 2017. Other numerical goals are:

- Global EV market share – 10% by 2020
- Domestic EV share in small car market – 12% by 2015
- Domestic EV share in overall market – 22% by 2020
- Greenhouse gas emission reduction by dissemination of EV – 1.2 million tonnes by 2020
- Dissemination goal of 800, 13,200 and 85,000 accumulated in 2011, 2013 and 2015, respectively.

Targets for production and R&D are also stated in this roadmap. The chart below indicates the projection of green car production as forecasted in 2010.

The deployment of EVs and other green cars has been slow and the general consensus among stakeholder is that the roadmap is too ambitious and the goals difficult to meet. The process of drawing a new roadmap is expected to start soon, with the involvement of the Ministry of Knowledge Economy, the Ministry of Environment, the Ministry of Land, Transport and Maritime Affairs and the Ministry of Finance. The new roadmap is to be established based on the technologies’ development and international policy trends, as Korean car manufacturers depend heavily on exports.

At the same, the government announced its Strategy for Developing Green Car Industry, which called for policy measures to include tax credits and subsidies, bonus and malnus, support for charging facility installations, and selecting EV deployment leading cities for pilot projects.

Type		Start	'11	'12	'13	'14	'15
EV	Compact	'10	MP				
	Compact CUV	'11	R&D	MP			
	Midsize	'11	R&D			MP	
	Remodeled	'12		R&D		MP	
	Bus Remodeled	'10	R&D				Demo/MP
PHEV	Midsize	'08	R&D	Demo	MP		
HEV	Compact	'00	MP('10~)				
	Midsize	'06	MP('11~)				
FCEV	Midsize	'04	R&D	Demo			MP
	Bus	'06	R&D				Demo/MP
CDV	Midsize	'10	R&D	MP			
	Fullsize	'12		R&D		MP	
	Bus	'13			R&D		MP

MP= mass production

Figure 1-2 Projection of production of green vehicles

### Green Car Deployment Target

As part of the evaluation of policies promoting growth of green car industry conducted and reported to the prime minister as part of the green growth policy, the target for green car deployment is as follows:

Category		2011	2013	2015	2020
<b>Registered Vehicles/Total</b>		18,100	19,300	20,130	22,190
<b>Green Car</b>	<b>Electric</b>	0.8	23.2	129.7	1294.2
	<b>Hybrid</b>	30.5	78.5	151.5	405.5
	<b>Clean Diesel</b>	330.6	719.85	1114.3	1952.3
	<b>Subtotal</b>	361.9	821.55	1,395.50	3,652
<b>Market share for Green Car</b>		14%	17%	21%	43%

Figure 1-3 Green Car Deployment Target as of August 2011

(Accumulative numbers reported in thousands)

Source: Hwang, 2012<sup>2</sup>

### 1.1.3 Main actors and networks

#### The central government and related actors

The Law for Development and Deployment of Environment-friendly Vehicles passed in 2004 set the legal framework for the relevant ministries to commit to promotion of green vehicles. The role of the central government is to promote deployment of electric vehicles

<sup>2</sup> Hwang, S. K. (2012). *Electric Vehicles in Operation, in Lessons from Transition in Urban Transport Policy* (pp. 142-160). Korean Transport Institute.

by providing subsidies to consumers and provide funding for R&D. The effectiveness of both measures will be discussed in later sections.

#### *Presidential Committee for Green Growth (PCGG)*

Since President Lee's inauguration in 2008, policies to realize a green growth have become a central pillar in policy making in Korea. Promotion of green cars has been an essential and a prioritized topic for President Lee's administration. PCGG is the governing and coordination body of all central government ministries on green growth and all policies related to promotion of green cars are heavily pushed for implementation, reported to and evaluated by PCGG. Based on the evaluation, further direction on the policy has been provided in a "top-down" format, with a strong leadership. With a new president taking office in February 2013, the issue's priority is yet to be made clear.

President Lee's leadership in promoting EV was shown when he made an unprecedented visit to Hyundai to promote further investment in the manufacturing of EVs when the Green Car Forum was convened in 2010.

#### *Ministry of Knowledge Economy (MKE)*

The MKE leads policies regarding vehicle technologies for automobiles and their parts. It has worked with the industry for production of EV and other green cars. Internal policy discussions at the MKE have led to the decision that their funding should focus more on R&D. The MKE has also led the "Green Car Forum" in association with EV experts from government, academia and business sectors to establish detailed strategies for the development and commercialization of green cars.

#### *Green Car Forum*

The Green Car Forum was convened by the government in 2010 as an advisory body to the government to develop a roadmap to help the country become one of the top four eco-friendly green car manufacturers by 2015. The Forum consists of approximately 500 members from government, academia and the private sector. In Korea, an advisory body consisting of multiple stakeholders in the policy making process is quite usual but it is rare to have 500 members.

#### *Korea Automotive Technology Institute*

The Korea Automotive Technology Institute is a semi-governmental organization which serves as the secretariat for the Green Car Forum. It functions both as a research body and a think-tank for the government. It has an extensive network in the field and is one of the important players in green car policies in Korea.

#### *Ministry of Environment*

The Ministry of Environment is responsible for the diffusion of EVs and other green cars. It has run a subsidy scheme for purchases of EVs and provided tax credits for the public sector. The ministry also has close contacts with the industry, for example it is in regular contact with manufacturers to decide on the pricing of the vehicles.

#### *Ministry of Land, Transport and Maritime Affairs*

The Ministry of Land, Transport and Maritime Affairs is responsible for the deployment infrastructures, as well as vehicle safety inspections for EVs. The ministry also runs pro-

grammes to exempt or reduce fees for using infrastructure such as toll roads and parking spaces to provide incentives for EV drivers.

#### *National research institutes*

The Korea Transport Institute (KOTI) and the Korea Institute of Science and Technology (KAIST), play a role in development of new technologies for EV and its infrastructure. KOTI, an entity reporting to the Ministry of Land, Transport and Maritime Affairs, has provided technical and policy intelligence in determining the safety standard and building infrastructure. KOTI has conducted a survey of 118 experts in EV, research and development, interest groups, and transportation. The questionnaires included issues regarding policy goals and pursuant to the policy speeds for EV-development and deployment, timing for EV market border opening to overseas players, related technologies, and government supports.

KAIST has invented the Online Electric Vehicle (OLEV), which allows recharging while driving on the road by converting the magnetic field generated from electric power strips buried under the road surface into power. A feasibility study was conducted but technical barriers have prohibited the system from being implemented on public roads and it continues to be operated experimentally as a shuttle inside an amusement park.

#### 1.1.4 Local government

Municipalities play a role in designating infrastructure for EVs in addition to running pilot projects utilizing EVs. Of the local government implementing measures/projects utilizing EV, the city of Seoul is one of the most active.

##### *Seoul Metropolitan Government*

The city of Seoul is a front-runner in local efforts to promote deployment of EVs. Its EV promotion history began in 2008 when the city supported deployment of 20 electric powered motorcycles for pizza delivery. The project was not a success but the city's efforts to promote EVs have continued and include the NamSan electric bus and taxi service for the handicapped which is described in later sections. The Master Plan for EV Deployment in Seoul was established in 2011.

#### 1.1.5 Private sector

There are many Korean companies, including automobile manufacturers KIA and Hyundai, who are involved in development of EVs, the infrastructure and parts and components such as battery, inverter, motor, chargers, etc. EV manufacturers continue to ask the government for an early establishment of charging infrastructure and reduced power rates and car grants to encourage the purchase of EVs.<sup>3</sup>

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<sup>3</sup> Lee, A. V.-M. (2010). *Electric Vehicles in South Korea*. Retrieved from <http://www.finpro.fi/documents/10304/9b52fef5-e0d1-4938-8ec8-961ea6c87491>

TYPE	FSEV			NEV		ELECTRIC BUS	
Maker	Hyundai Motor	Renault Samsung	GM Daewoo	CT&T	AD Motors	Hyundai Motor	Hankuk Fiber
EV model	 Blue On Compact car	 SM3 Compact mid size sedan	 Lacetti Compact mid size sedan	 e-Zone Compact car	 Change Compact car	 Elec-city Low-floor bus	 e-Primus Low-floor bus
Seat	4	5	5	2	2	51	49
Max speed	130km/h	140km/h	165km/h	60km/h	60km/h	100km/h	100km/h
Drive range /Single charge	140km	160km	160km	100km	120km	120km	120km
Battery	Lithium-ion polymer 16.4kW/h	Lithium-ion polymer 24kW/h	Lithium-ion polymer 31kW/h	Lithium polymer 10.1kW/h	Lithium iron-phosphate 10kW/h	Lithium-ion polymer 95kW/h	Lithium-ion 102kW/h

Figure 1-4 Line-up of major EV models

FSEV= full-scale EV, NEV=Neighbouring EV

Source: Lee, 2010<sup>4</sup>

Korean companies are known to have world-class battery technologies, where Samsung, SDI and LG Chem have over 40% global market share <sup>5</sup>.

*Korea Automobile Manufacturers Association (KAMA)*

KAMA is a non-profit organization and lobbying organization, representing the interests of automakers in South Korea, namely Hyundai, Kia Motors, GM Korea Company, Renault Samsung and Ssangyong. KAMA works with climate change and energy security issues involving the automobile sector and sharing the importance of electric vehicles and green cars to overcome the challenges Korea face in the field. The organization provides policy suggestions to the government and has good communication channels with the Ministry of Knowledge Economy and the Ministry of Environment. KAMA has been involved in the Green Car Forum and also the feasibility studies on EV infrastructure on the island of Jeju.

**1.2 Functional pattern of EVs in South Korea**

This section describes the governance structure for electrification of the vehicle fleet in South Korea, based on the innovation system functions identified in the TIS framework.<sup>6</sup>

**1.2.1 Development, direction and diffusion of knowledge**

*R&D in core technologies in green cars*

As reported in the evaluation of policies promoting growth of green car industry to the Prime Minister in 2011, eight R&D topics have been selected in February 2011 and in July, the responsible parties for the execution of R&D have been selected and full-scale support on the identified topics has been implemented. The eight topics identified are listed below.

<sup>4</sup> Lee, A. V.-M. (2010). *Electric Vehicles in South Korea*. Retrieved from <http://www.finpro.fi/documents/10304/9b52fef5-e0d1-4938-8ec8-961ea6c87491>

<sup>5</sup> Kim, S.-M. (April 27, 2012). *Korean Secondary Battery Leaping 10 years, Overtaking Japan*. Korea IT Times, ss. <http://www.koreaitimes.com/story/21199/korean-secondary-battery-leaping-10-years-overtaking-japan>.

<sup>6</sup> For more info on the TIS framework, see Bergek et al (2008) Analyzing the functional dynamics of technological innovation systems: A scheme of analysis, 2008, *Research Policy*, (37), 3, 407-429.

Table 1-1 Top R&amp;D topics identified

HEV	Efficiency in power transmission device
Clean Diesel	Domestic production of high pressure fuel injection system
EV	R&D in Motor, HVAC (Heating, Ventilation and Air Conditioning), Size Reduction, Battery and Charger
FC	Stack

The R&D of five EV technologies is to be concluded by the end of 2013 and applied in mass production by the end of 2014. The remaining R&D topics are to be concluded by the end of 2015.

The numerical target for the EV technologies is shown in the figure below:

Items		'11	'12	'13	'14	'15	
EV	Motor	Output (kW/ℓ)	2.9	2.9	3.0	3.1	3.2
		Efficiency (%)	85	86.5	88	90	92
	HVAC	Loss (%)	30	22.5	15	12.5	10
	Size Reduction	Total Size (%)	100	95	90	85	80
		Parts (%)	100	100	90	85	80
	Battery	Distance (km)	140	140	150	180	200
		Price (\$/kWh)	1,000	900	800	600	500
	Charger	Slow Charge (hr)	6	6	5	4	3
		Quick Charge (min)	25	23.5	22	21	20

Figure 1-5 R&amp;D targets

Source: Kim D.<sup>7</sup>

## 1.2.2 Market formation

### *Policy for EV Dissemination*

A stimulus plan has been established to promote customer demand that includes tax exemptions to be granted to EVs between 2012 and 2014. Maximum tax exemption is \$3,500 (KRW 4,200,000). For small vehicles a total of \$5,800 (KRW 7 million) is provided along with other incentives (such as benefits for light-weight vehicles). An EV bonus of \$12,500 (KRW 15,000,000) is provided for procurement by the public sector for 2012. Additionally, other incentives are provided to promote purchase and ownership of EVs such as exemption from congestion and parking charges, discount on highway tolls, EV-only parking

<sup>7</sup> Kim, D. (u.d.). *Green Car Roadmap*. 36th EGNRET.

spaces. etc. For 2012, a total KRW 50 million was allocated in subsidies, but only KRW 27 million was utilized, making visible the lack of demand from the public sector. Currently, the subsidy only covers domestic-made EVs. However, as Korea has numerous free-trade-agreements (FTA), it is difficult to keep favouring domestic manufacturers. Additionally, as most of the manufacturers are export-oriented, it is in their interest to promote an open market in general and provide equal subsidy opportunities for both domestic and foreign-made vehicles, even it means foreign manufacturers will enter the Korean market.

### *Neighbouring EV-NEV*

In order to promote the use of EVs even when full-fledged, full-speed EV was not available, the Ministry of Environment has promoted Neighbourhood EV (NEV). NEV is a smaller vehicle with a maximum speed of 60 kilometres per hour. The Ministry of Land, Transport and Maritime Affairs provided legal grounds for driving NEVs on conventional road by amending the Vehicle Management Law in 2009. Currently, NEVs are banned on conventional roads where the minimum speed is over 60 kilometres per hour. The impact of the policy to promote NEV has been very limited as it was only geared towards the public sector and the specifications of NEVs were far from those of conventional vehicles.

### *EV-Leading City*

In cooperation with the Ministry of Knowledge Economy, the Ministry of Environment has been running a project called “EV-Leading City” since 2011 and has selected eight cities including Seoul and Jeju. The selected municipalities utilize financial support from the central government to purchase electric vehicles and to establish charging infrastructure. The cities are currently being evaluated and the number of designated cities is expected to be reduced to six<sup>8</sup>.

### *Pilot projects in the city of Seoul*

#### **Namsan Electric Bus**

In 2010, the city of Seoul introduced an EV bus system with five EV buses and as of January 2013 ten EV buses which run for 80 kilometres on a single charge are in operation on the NamSan circular line. The city has a goal to deploy 3,800 buses.

An EV bus costs approximately 2.5 times more than a conventional bus and it is funded solely by the city of Seoul. The city has signed a memorandum of understanding with HanKuk Fiber Co. Ltd. and Hyundai Heavy Industry, guaranteeing an Advance Purchase Commitment in August 2009 to encourage the manufacturers to develop technologies for buses that are in low demand. The city of Seoul is responsible for the overall project management including deployment of EV buses, route operation, and establishing the infrastructure, while Hankuk Fiber and Hyundai Heavy Industry are responsible for production and maintenance of the bus and the technology development of motors and inverters, respectively.

#### **Taxi for the handicapped**

Seoul Metropolitan Government runs pilot projects utilizing funding from the central government. Ten EVs in the total fleet of 300 vehicles were introduced in the taxi service for the handicapped operated by the Seoul Metropolitan Government between October and December 2012, using KIA Ray and a quick charger that is able to charge in 30 minutes.

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<sup>8</sup> Interview: *Environment, M. o.* (January 10, 2013).



The evaluation of the project to base the decision on full-scale deployment of the project is being conducted by Seoul Institute.

### **Car sharing**

Seoul City will start running a car-sharing programme in February 2013, utilizing 200 EVs, 40 quick chargers which can charge in 25 minutes and 70 standard chargers.

### **1.2.3 Legitimation**

#### *EV as part of Green Growth Policy*

Policies to promote EV include technology development and standardization, revising regulations and codes, pilot projects and demonstrations and stimulating EV deployment. EV was one of the ten green growth engines in the last administration and the government has promoted its deployment, including by providing concentrated R&D investment of 400 billion KRW on high-performance batteries and other related systems<sup>9</sup>.

#### *Policy on Infrastructure*

A roadmap for establishing infrastructure was supposed to be announced in 2011, but it was never drawn. Currently existing charging stations installed by the government use the ChaDeMo interface, as requested by the industry. However, the international trend is not necessarily favourable to ChaDeMo. The government, particularly the MKE, feels the necessity to make a decision on which interface Korean car manufacturers are to use. However, the government has not been able to make the decision as yet. Additionally, government feels the dilemma of not proactively leading the international discussions on the issue, as this situation calls for them to become a follower.

#### *Evaluation of policies promoting growth of the green car industry*

As with all other green growth related policies, the evaluation of policies supporting growth of the green car industry was reported to the Prime Minister's Office in 2011. The evaluation was conducted at a series of meetings which assembled the members of the subcommittee of the PCGG, an expert panel from the private sector and the relevant ministries. The evaluation called for strengthening of structure to further promote the industry. The following recommendations were made:

- Break-down of the target by establishing mid-term and bi-annual targets per involved ministry and governmental agency
- Further efforts to increase demand by June 2012
- Install emergency charging stations and a system to manage the charging infrastructure by December 2012

### **1.2.4 Resource mobilisation**

In the Action Plan indicated in the Green Car Roadmap in 2010, the following governmental funding of approximately SEK 9 billion is specified for promotion of green cars. Approximately half of the intended funding is allocated for the subsidy for purchasing green cars. Remaining measures receiving substantial funding are installation of the charging infrastructure and R&D in core components.

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<sup>9</sup> Lee, A. V.-M. (2010). *Electric Vehicles in South Korea*. Retrieved from <http://www.finpro.fi/documents/10304/9b52fef5-e0d1-4938-8ec8-961ea6c87491>

Table 1-2 Budget allocation for promotion of green cars

Issues		(unit: 100 million KRW)	(unit: million SEK)	Years
		Won	SEK	
Strategic R&D for core components				
R&D for core components		1,570	919	2011-15
Support for domestic production and improved efficiency of core components		1000	586	2011-15
Market creation and establishment of Infrastructure				
Subsidies and tax benefit				
Subsidies for acquisition by public sector		3286	1924	2011-15
Subsidies for acquisition of retrofitted EV		5000	2928	2004-14
Establishment of Infrastructure				
Electric charger	by public sector	2350	1376	2011-15
	by private sector	827	484	2011-15
Hydrogen charger		813	476	2012-15
R&D in charging technologies (Bus stop & Removable batteries)		96	56	2011-15
Creation of sustainable industrial ecosystem				
Establishing regulations on verification of safety		398	233	2011-2012
Nurturing experts on green cars		40.5	24	2011-15
Standardization		99.5	58	2011-15
Authentication service	Domestic	100	59	2011-15
	Abroad	220	129	2011-15
		Total	9,124	

Source: Ministry of Knowledge Economy, 2010<sup>10</sup>

### 1.3 Conclusions

Levelling of fuel prices decelerated the original momentum to roll-out EV and infrastructure and has delayed implementation of some of the intended policies. This has delayed introduction of EVs to the market.

According to McKinsey's Electric Vehicle Index (EVI), an index compiled by McKinsey based on both supply market maturity (EV share of car sales, economic advantage of EV, additional incentives for EV drivers (e.g. bus lane access) and demand market maturity (forecasted EV share in car production, number of national OEM EV prototypes, government support for infrastructure and R&D), Korea has failed to advance in 2012 compared to 2010, while other countries increased their "EV readiness"<sup>11</sup>.

The general consensus is that the targets established for deployment of EV and its related infrastructure will not be met and need to be revised. Although the important actors in the central government and the private sector are well-connected and share the general sentiment for the need of EVs, the policies implemented have not been able to overcome the barriers of market penetration such as high price of vehicles, technological development and lack of development of the infrastructure to meet the travel needs met by conventional vehicles. The government has not been able to make the market more attractive for the private sector to enter the market. Some of the interviewees suggested un-matching interest between the government and the private sector has resulted in manufacturers choosing to diversify their portfolio in green vehicles, rather than focusing on EVs, while the government focused on EV alone.

KAMA, representing the interest of the automobile manufacturers, asks the central government for more investment in R&D, especially in the core parts and nurturing the experts

<sup>10</sup> Ministry of Knowledge Economy. (2010). *Announcement of Green Car Roadmap (in Korean)*. Seoul.

<sup>11</sup> McKinsey & Company, 2012

in the field, in addition to establishing regulations on safety. It also states a clear policy direction is crucially important for the private sector to decrease the investment risk.

Since later in 2012, the general direction of policy is starting to steer towards diversifying the green car portfolio, compared to a focus on electric vehicles alone. However, the best portfolio and the fate of EV deployment is yet to be determined as, again, it waits for the direction to be announced by the new president.

## 2 India

### 2.1 Introduction

There are around 1,350 four-wheel passenger Electric Vehicles on the roads in India, and approximately 500, 000 electric two-wheelers. India has an ambition to have 6-7 million electric vehicles on the roads by 2020. Two-thirds of this figure will be two wheelers with around 1.6 million four wheelers. India's shift towards electric vehicles is driven by a desire to reduce dependence on imported fuels, continue to build local automotive manufacturing capabilities in line with global demands, and play an active role in placing India on a sustainable growth trajectory. To reach such high targets will require the coordinated efforts of a broad set of stakeholders across government, industry and research oriented institutions.

The Prime Minister of India, Dr Manmohan Singh, recently released the National Electric Mobility Mission Plan 2020 (NEMMP 2020) which sets out the framework to make the Electric Mobility ambition a reality. Development of the NEMMP has been an inclusive process that builds on past collaborative successes. Stakeholders are confident that the policy takes into account lessons from earlier attempts to establish interest in EVs – especially a stable regulatory environment and long-term signals to provide confidence for business decision making.

The NEMMP identifies three working groups around which detailed plans and incentive strategies will be developed. This highlights the emphasis on ensuring that appropriate frameworks are in place to develop interest and demand, increase manufacturer interest and capability, increase R&D and build adequate supporting infrastructure.

The Electric Mobility ecosystem is in its infancy. The NEMMP sets out a vision for how this ecosystem will mature to take India into a leading position in xEVs – a term coined by the team behind the NEMMP to encompass the full gamut of electric vehicle options.

### 2.2 Background

Since economic liberalisation began in 1991 India's GDP has seen relatively high growth rates, but due to a range of global and local factor this growth has begun to slow. The 12<sup>th</sup> Five Year Plan<sup>12</sup> lays a foundation for growth in the region of 5.0-8.2%<sup>13</sup>, with the lower end of the forecast coming into place if a number of systemic issues, such as slow policy decision making, continue. This growth story brings with it a number of challenges: catering to a diverse set of economic situations and the need for inclusive growth; developing education and skills and dealing with infrastructure pressures wrought by large scale urban migration.

India's demographic shift toward urban centres largely mirrors a worldwide trend. Millions of people have shifted towards urban centres such as Delhi, Mumbai and Bangalore. This places extraordinary pressure on resources and infrastructure. With growing economic prosperity in a number of segments of the population there has also been a large growth in disposable income. This shift has been played out in increased consumer activity across the

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<sup>12</sup> India operates five-year planning cycles to act as a guide to economic development. The plans are developed and overseen by the Planning Commission, Government of India.

<sup>13</sup> [http://articles.economictimes.indiatimes.com/2012-09-14/news/33844176\\_1\\_12th-plan-gdp-growth-fiscal-deficit](http://articles.economictimes.indiatimes.com/2012-09-14/news/33844176_1_12th-plan-gdp-growth-fiscal-deficit)

economy and car purchase is the second largest purchase an individual will make after a house.

Until recently the transport sector continued to record robust growth figures amongst poorer economic news, and recorded 13% annual growth in the last five years<sup>14</sup>. However, the automotive sector has not been immune to negative economic sentiments and is currently facing falling sales. Negative economic sentiment, coupled with high interest rates and rising fuel costs are worrying manufacturers. It is estimated that industry sales for the period 2012-13 will grow in the range of 5-7%, lower than the earlier forecast of 11-13%.<sup>15</sup>

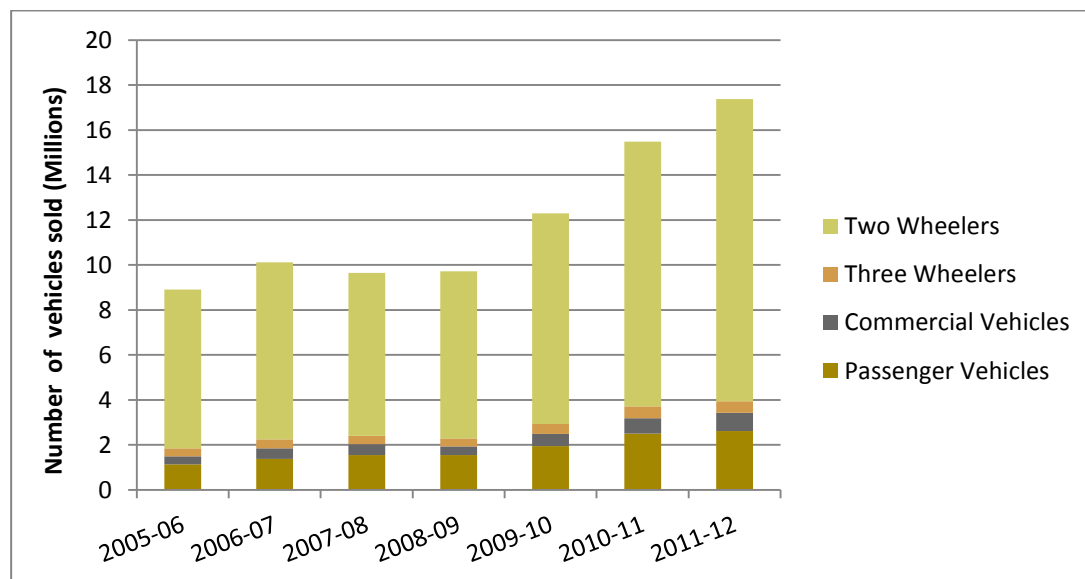


Figure 2-1 Growth of vehicle sales in India (2005-6 to 2011-12)

Source: [www.siamonline.in](http://www.siamonline.in)

It is estimated that by 2020 sales of cars and two wheelers in India will reach 2.7 million and 30 million respectively. India's car manufacturing industry is currently the 6<sup>th</sup> largest in the world, and provides direct and indirect employment to approximately 13.1 million people<sup>16</sup>. The employment generation potential and flow on benefits through the economy in general makes the automotive sector key to government plans. From a production base of 2 million vehicles per year in 1991, domestic production had expanded to over 20 million units for the period 2011 - 2012. Turnover for the industry had reached USD 53.1 Billion (Rs 239, 000 Cr) and the contribution of the automotive industry to the economy had grown from 2.77% in 1992-93 to close to 6% in 2011-12.<sup>17</sup> But at 11 cars per 1000 people, the present level of penetration is amongst the lowest in the world, leaving signifi-

<sup>14</sup> [www.siam.com](http://www.siam.com)

<sup>15</sup> <http://www.thehindubusinessline.com/companies/article3984218.ece>

<sup>16</sup> Department of Heavy Industry, Ministry of Heavy Industries and Public Enterprises; Report of the Working Group on Automotive Sector for the 12th Five Year Plan (2012 – 2017) <http://dhi.nic.in/Auto%20report%20final.pdf>, Page 13

<sup>17</sup> Department of Heavy Industry, Ministry of Heavy Industries and Public Enterprises; Report of the Working Group on Automotive Sector for the 12th Five Year Plan (2012 – 2017) <http://dhi.nic.in/Auto%20report%20final.pdf>, Page 12

cant headroom for growth in the market.<sup>18</sup> Growth potential makes this an important sector for the economy, even if times are tough today.

The sector's overall growth can be traced to liberalisation and growing income levels. But the development of the Automotive Mission Plan 2006 – 2016 is often referred to as a point when the ambition to become a hub for global manufacturing was clearly elucidated. It is also a strong reference point for broad engagement of stakeholders across the automotive sector, including government, industry and academia.

The AMP 2006 – 2016 stated a vision for India's automotive sector:

*“To emerge as the destination of choice in the world for design and manufacture of automobiles and auto components with output reaching a level of US\$ 145 billion accounting for more than 10% of the GDP and providing additional employment to 25 million people by 2016.”*

Strong and deep relationships throughout the automotive sector, spurred by the government's desire to move away from a dependence on fossil fuels in the transport sector, has in part lead to a coordinated effort to develop a framework to support development of a vibrant electric vehicle market in India.

### 2.2.1 The National Electric Mobility Mission Plan 2020: Moving into Mission Mode to enhance Electric Mobility

India is a net oil importer and escalating costs are having knock-on effects throughout the economy. In the 2011-12, financial year India's import bill increased by 40%. Estimates suggest that the transport sector accounts for about one third of India's crude oil consumption, road transportation accounting for almost 80% of this figure.<sup>19</sup> The Government realises the importance of weaning the transport sector off fossil fuels, especially from a perspective of domestic fuel security, and sees electrification as an important part of the solution. The NEMMP highlights potential fuel cost savings in the range of 39,000-43,000 Crore (approx. 8 Billion USD – 8.8 Billion USD) by 2020 if a proactive approach is taken to implementing electric mobility across segments). In June 2008 the government also launched its National Action Plan on Climate Change, outlining 8 missions to combat the effects of climate change. Work is going on to elucidate a low carbon growth pathway for India and the need for climate change action has been a factor in the development of the NEMMP.

In March 2011 the Union Cabinet approved a proposal to establish a National Mission for Electric Mobility (NMEM). The goal of the NMEM would be to promote electric mobility and manufacture of electric vehicles throughout India.

There is recognition of a number of challenges and barriers to uptake of Electric Vehicles in India, e.g. higher upfront cost, lack of consumer familiarity with technologies, lack of adequate charging infrastructure, limited domestic manufacturing capabilities, and lack of targeted government support.

To overcome these barriers the government began the process of developing the National Electric Mobility Mission Plan 2020. This process aims to be collaborative and open, tak-

<sup>18</sup> Department of Heavy Industry, and Public Enterprises, Ministry of Heavy Industries and National Electric Mobility Mission Plan 2020, Page 10

<sup>19</sup> <http://www.siamonline.in/HEV-EV-Mission-Plan-2020-Request-for-Proposal.pdf>

ing into account the views of a wide range of stakeholders and establishing both short and long term objectives.

The NEMMP was released by the prime minister in January 2013 and sets out the vision to develop a vibrant ecosystem for electric mobility in India. The document outlines a roadmap for xEVs in India – a generic term that captures Hybrid Electric Vehicles (HEVs), Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs). Where possible our discussion will break out to focus on HEVs, but the term largely used in this report will be xEV, with a focus on passenger cars (‘four wheelers’).

The NEMMP has a broad vision statement:

- “To encourage reliable, affordable and efficient xEVs that meet consumer performance and price expectations through Government – Industry collaboration for promotion and development of indigenous manufacturing capabilities, required infrastructure, consumer awareness and technology; thereby helping India to emerge as a leader in the xEV Two Wheeler and Four Wheeler market in the world by 2020, with total xEV sales of 6-7 million units thus enabling Indian automotive industry to achieve global xEV manufacturing leadership and contributing towards National Fuel Security”<sup>20</sup>

To go from a base of well under 1 million units to 6-7 million units will require collaboration and commitment from government and industry, as well as buy-in from apprehensive consumers.

## 2.3 Building a Collaborative Approach: Main Actors and Networks

There has been a confluence of positive factors in developing the NEMMP, including a number of dynamic individuals within government, industry and associations driving forward initiatives. Participants have also benefited from trust that has been built up over a period of time, especially through the process of developing the Automotive Mission Plan 2006 – 2016. The NEMMP development process was approached as an inclusive large-scale change management programme<sup>21</sup>, and benefited from the broad consensus that was developed closely with industry. All stakeholders spoken to were very positive about the process undertaken to develop the NEMMP and the collaborative efforts of all those involved.

Broader factors have also helped spur collaborative efforts. The government’s desire to ensure fuel security, as well as an impetus towards developing and strengthening India’s manufacturing capability provide focus to policy makers when establishing frameworks. The automotive sector has significant upstream and downstream employment generation potential which makes it an important sector for government.

### 2.3.1 Role of the State in Electric Mobility Development in India

In 2010-11, the contribution of the automotive industry to manufacturing GDP and excise duty was 22% and 21% respectively.<sup>22</sup> This makes the automotive industry important to

<sup>20</sup> Department of Heavy Industry, and Public Enterprises, Ministry of Heavy Industries and National Electric Mobility Mission Plan 2020, Vision Statement

<sup>21</sup> Stakeholder discussion, January 2013

<sup>22</sup> Department of Heavy Industry, Ministry of Heavy Industries and Public Enterprises; Report of the Working Group on Automotive Sector for the 12th Five Year Plan (2012 – 2017) <http://dhi.nic.in/Auto%20report%20final.pdf>, page 10

the government from both an ancillary employment generation and a revenue collection perspective.

The Department of Heavy Industry (under the Ministry of Heavy Industries and Manufacturing) is the nodal department for electric mobility. The policy development process has been driven by a director at the National Automotive Testing and R&D Infrastructure Project (NATRiP) which operates as part of the NATRiP Implementation Society (NATiS).

NATRiP aims to create Testing, Validation and R&D Infrastructure throughout the country, and will continue to play a role driving the NEMMP policy process until the National Automotive Board is established. Discussions with NATRiP indicated that an inclusive process has been undertaken by government departments to evolve the policy with the problem being approached as a large-scale change management programme. The relationship between government and industry, as observed from stakeholder discussions, is quite collaborative. This relationship was built on the back of strong engagement ahead of the development of the Automotive Mission Plan 2006 – 2016 and has been further enhanced over the course of the NEMMP process.

In the past there have been fragmented approaches to develop electric mobility. The NEMMP process has sought to overcome this by early and broad engagement. Key departments consulted through the process include the Ministry of New and Renewable Energy (MNRE), the National Manufacturing Competitiveness Council (NMCC), the Department of Science and Technology (DST), the Department of Industrial Policy and Promotion (DIPP), the Ministry of Finance, the Ministry of Environment and Forests and the Ministry of Urban Development.

At the time of cabinet approval of the NMEM, a governance structure was put in place to expedite decision making and implementation. The structure comprises a National Council on Electric Mobility (NCEM), a National Board for Electric Mobility (NBEM) and a National Automotive Board (NAB).

Table 2-1 Governance Structure to push forward the mission

<b>A National Council for Electric Mobility</b>	<b>An 18-member initiative with minister level participation and well as representation from academia, industry and research.</b>
A National Board for Electric Mobility	A 25-member multi-stakeholder body with representation at secretary level, as well as representation from industry associations and business leaders
National Automotive Board	The National Automotive Board will be responsible for all EV technical and domain expertise (including manufacturing). This will also involve policy analysis, as well as appraisal of various schemes implemented under the mission. The working group for the 12 <sup>th</sup> five year plan has earmarked 205 Crore (USD 39 million) over the plan period 2012 – 2017 for operating the NAB. Currently this coordination role is being played the NATRiP Implementation Society (NATiS), a body established to oversee the National Automotive Testing, R&D Infrastructure Program.

Source: NEMMP

The NCEM would act as the apex body for the mission, taking control of decision making with the intention of taking decisions quickly. The NBEM would be a group of empowered



government officials and industry leaders, and the NAB (yet to be formed) would provide timely and accurate inputs to both the NBEM and NCEM to aid in decision making.

Most policy making will take place at the NBEM level, with escalation to NCEM for sign off.

The central government has a decisive role to play in the development of the sector. This will primarily be through the types of incentive structures put in place, both from a demand and supply perspective. It will also be important that states are encouraged to also develop incentives alongside the central policies. To date, Karnataka and Delhi have helped build support for EVs with demand side subsidies in addition to Value Added Tax (VAT) and road tax waivers. A number of other states have also reduced VAT, but efforts remain fairly fragmented.

### 2.3.2 The important Role of non-Government Actors, Networks and Industry Players

There are 19 original equipment manufacturers (OEMs) in India, with the majority of automobile makers represented. There is limited activity on the xEV front from these companies. This is in part due to lack of an enabling framework from government, insufficient demand and no mandate from many overseas head offices.

Nonetheless, there has been strong engagement from the industry in general throughout the process of developing the NEMMP. Discussions with stakeholders highlighted the fact that even though there were no immediate plans to launch xEVs, the importance of developing a robust roadmap for implementation of EVs was recognised and duly supported by industry players. This has led to an impressive level of collaboration among industry players to develop the mission. As mentioned, this commitment was brought about through the involvement of dynamic individuals at the government level, as well as experienced individuals at the private sector level who realised early on the importance of the electrification of the vehicle fleet and the need for a collaborative and inclusive approach to learn from previous efforts and build a sustainable approach to xEVs in the future.

Industry associations also played a large part in consultations and consensus building. For example, the Society of Indian Automobile Manufacturers (SIAM) was involved in a) commissioning a report on the potential for EVs in India (carried out by consultants Booz and Company) and b) establishing a steering committee of industry representatives. There appears to be a great deal of trust between the government and SIAM that has developed over a period of time. Along with SIAM a number of other networks and associations played a role in the policy making process, including the Automobile Component Manufacturers Association of India (ACMA), the Society of Manufacturers of Electric Vehicles and the Battery Manufacturers Association. It is important that each of these parts of the xEV ecosystem be represented, given the need to develop capabilities along the entire value chain.

## 2.4 Functional Pattern of Electric Mobility in India

This section describes the governance structure for electrification of the vehicle fleet in India, based on the innovation system functions identified in the TIS framework.<sup>23</sup>

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<sup>23</sup> For more info on the TIS framework, see Bergek et al (2008) *Analyzing the functional dynamics of technological innovation systems: A scheme of analysis*, 2008, *Research Policy*, (37), 3, 407-429.

### 2.4.1 Development, direction and diffusion of knowledge

Technological and production capabilities of car makers in India have increased considerably. Given the lack of an electric mobility industry, domestic Research & Development in xEV components is limited. Activities that are under way are often fragmented in nature and often spread across ministries, companies and academic institutions. TVS (a two wheeler manufacturer), Mahindra Reva, Tata Motors and Hero Electric have made some progress in developing patents, but the bulk of research and development is carried out by overseas companies.

The government realizes the importance of robust R&D to enable Indian companies to be globally competitive. The NEMMP highlights battery cells and battery management system (BMS) technology as a priority, especially given the large cost component of batteries in xEVs. Other priorities identified include power train system integration, transmission systems, electric motors and power electronics.<sup>24</sup> These priorities are summarized in Table x below.

Table 2-2 R&D Priority areas

Priority Accorded	Focus Area
Priority 1	Battery Cell
Priority 2	Battery Management System
Priority 3	Power Electronics (Hybrids)
Priority 4	Electric Motor
Priority 5	Transmission System (Hybrids)

Source: NEMMP

Alongside this, the government has identified priority areas where there is greater potential for India to succeed, taking into account international competition and existing competencies. Where there is a high priority but hard-to-develop focus, it is envisaged that progress would be through global partnerships and acquisition of technologies.

It is recognized that for the xEV-R&D efforts to develop there will need to be significant involvement from the government to nurture a collaborative relationship. Stakeholders spoken to noted that there may realistically be limited opportunities for industry collaboration on R&D, but did look forward to the opportunities to integrate research activities with existing and developing R&D institutions. There is an expectation that industry participants, both domestic and international, will utilize this infrastructure for pre-competitive activities.

<sup>24</sup> Department of Heavy Industry, and Public Enterprises, Ministry of Heavy Industries and National Electric Mobility Mission Plan 2020, page 78

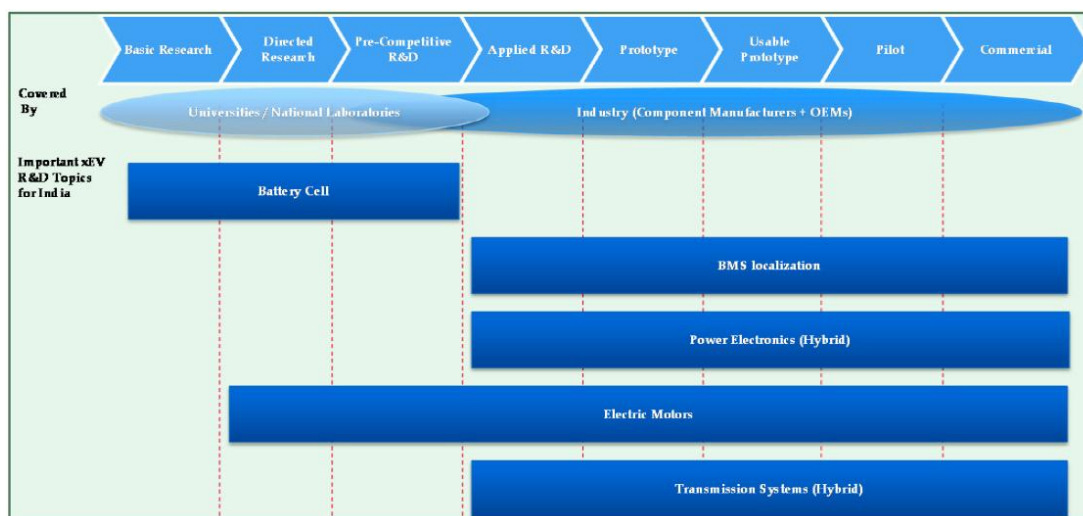


Figure 2-2 Approaches to R&D

Source: NEMMP

### *Bringing together research and development activities*

Recognising the need to bring together disparate activities, various stakeholders and government representatives the NEMMP called for an R&D focused working group. The WG-R&D will comprise key stakeholders from government, industry and academia. It will be responsible for developing detailed R&D plans, as well as ensuring ongoing monitoring of activities. The functioning of this group will be overseen by the NAB/NATiS.

The National Automotive Testing and Research Infrastructure Project (NATRiP) envisages setting up world-class automotive testing and homologation facilities in India at a cost of Rs 1,718 Cr (USD 324 million). Seven Centres of Excellence are being established around the country as part of the Indian government's desire to increase domestic Testing and R&D capacity.

The centres aim to help in:

- i. Creating core global competencies.
- ii. Enhancing competitive skills for product development leading to deepening of manufacturing.
- iii. Synergizing India's unique capabilities in Information Technology with the automotive sector.
- iv. Facilitating seamless integration of Indian automotive industry with the world to put India strongly on the global automotive map.<sup>25</sup>

The 12<sup>th</sup> plan earmarks a shift from a current focus of 'where' R&D is done (primarily in collaboration with government-approved in-house R&D units) to 'who' owns the IPR, thus enabling companies to undertake R&D in appropriate locations with organisations with the appropriate competencies. It is also expected that funds of around 740 Crore (USD 140 million) will be made available for xEV research over the 12<sup>th</sup> Plan period.<sup>26</sup> It is envis-

<sup>25</sup> <http://www.natrip.in/DisplayContents.aspx?menuid=239>

<sup>26</sup> <http://dhi.nic.in/Auto%20report%20final.pdf>

aged that the fund will be used in collaborative projects to develop new technology in EVs and hybrids. It is expected that there will be broad involvement from industry, government and research institutions.<sup>27</sup>

This approach should benefit market participants, especially those with overseas xEV competency such as Nissan, Toyota and Honda, who are interested in entering the Indian market but have not had the business proposition to develop manufacturing capacity or invest in R&D to cater for local conditions.

#### *A need for education for diffusion and knowledge development*

The xEV industry is at a very early stage with stakeholders interviewed recognizing the need for training programmes (vocational as well as tertiary academic). Currently there are no academic courses, though one stakeholder mentioned that there are 1-2 training institutions readying programmes for students, but are awaiting greater regulatory clarity and signs of increased demand.

### 2.4.2 Entrepreneurial experimentation: pockets of activity, but momentum of effort is needed for greater uptake

Overseas companies to have tested the waters for passenger HEVs in India include Toyota with its Prius and Honda with a hybrid Civic. Both cars are priced at a significant premium to equivalent vehicles. The Prius has sold 150 units since its India launch in 2010.<sup>28</sup>

Mahindra Reva (previously Reva) is India's most well-known electric vehicle manufacturer. The Reva car company has been in operation since 2001 with the Reva and Reva-i. In 2010 Mahindra & Mahindra, a large automotive company, bought a controlling stake in Reva, creating 'Mahindra Reva'. This new relationship provides Reva lee-way in the market to experiment and the company has set out a vision to introduce 5 new cars to the market over the coming years. Reva has continued to experiment with efficient manufacturing processes (pre-constructed space frames) as well as using complementary technologies (e.g. solar-powered charging stations for the cars' first charge). There are also a number of companies active in the two wheeler market, including TVS Motors and Hero Electric.

Currently companies are in watch mode as they wait for the market to develop. Domestically, Tata Motors, part of a large diversified conglomerate, has demonstrated concept cars at various international car shows, the most recent being the Tata Mega Pixel, a range-extended electric vehicle (battery plus fuel recharge). The car has been developed by Tata Technologies, a subsidiary of the Tata Group, with offices in India and Europe. Tata has also had an electric version of its Indica operating on a trial basis in some parts of Europe.

Ashok Leyland, another large Indian company, has also been developing hybrid buses for the Indian market. Buses are identified by the NEMMP as having great potential, especially as the buses return to a specific depot at the end of each day allowing for recharge infrastructure to be developed at the depot.

Charging infrastructure remains a major barrier to uptake of EVs (and a driver for potentially stronger interest in HEVs). This also presents an opportunity for innovative models for charging, e.g. charging stations at malls, property developers to combine solar energy and charging points into building design, and dedicated charging points at priority parking spots. These avenues need to be explored and may help foster entrepreneurial activity.

<sup>27</sup> <http://www.thehindubusinessline.com/industry-and-economy/article2671879.ece>

<sup>28</sup> <http://www.indianexpress.com/news/toyota-launches-new-prius/897001>

*Two-wheelers rule the road but clarity on subsidies is required to ensure a promising market develops further*

Two wheelers have by far in a way dominated India's EV market with large company Hero Cycles entering into partnership with Ultra Motor, a UK based company, to launch electric bikes in 2007. There are approximately 500,000 units on the roads, largely due to subsidies announced in 2010 by the MNRE. However, these subsidies were removed in March 2012 and some industry representatives say that the reduction in subsidies had led to a fall in sales in the region of 70%.<sup>29</sup>

Given the early stage of the policy it is yet to be seen whether the incentives envisaged to spur the R&D aspects of the market will indeed help drive deepening of the market and experimentation by entrepreneurs.

### 2.4.3 Market Formation

The xEV market has operated in a fairly uncertain environment and remains at a very early stage. High upfront cost, lack of customer awareness and stop-start incentives have not allowed steady demand for xEVs to develop. For example, Reva's sales statistics are telling: in terms of impact of incentives on sales, without incentives, only ~175 electric cars were sold each year in India (prior to introduction of subsidies by the MNRE in November 2010). In contrast, during the period from Nov 2010 to Mar 2012 when incentives were available, ~700 electric cars were sold in India.<sup>30</sup> However, sales are at a near standstill as Reva waits for announcement of subsidies under the NEMMP which will enable them to launch its new flagship vehicle, the e2o.

On the whole, a marketplace does not yet exist. There are no clear incentives, demand is unclear and adequate infrastructure is lacking. However, there is optimism that the NEMMP if implemented properly can help shift this market from a 'nursing market' to a 'bridging' and eventually mature market.

Market participants will be going through a learning phase and policy makers are keen to ensure that there are appropriate feedback loops to ensure that results of experimentation and market entry activity can be addressed in policy making going forward.

*Demand side aspects of market formation*

India's car market is made up of discerning customers that are a) extremely price conscious, and b) conscious of the fuel efficiency of their vehicles. Car makers are acutely aware of this when designing vehicles of all sizes. Upfront cost is one of the key barriers to uptake of xEVs and something of which both industry and government are acutely aware.

Prior to the launch of the NEMMP, the Alternate Fuels for Surface Transport Program (AFSTP) administered by the Ministry for New and Renewable Energy provides the major demand side incentives to consumers. For a passenger car the subsidy would amount to 20% or Rs 1 Lakh (USD 1,890). However, this scheme came to a close in 2012 and has brought the xEV market to a near halt.

Through the process of developing the NEMMP several interesting insights were garnered from potential customers which led policy makers understand the difficulties in establishing an incentive structure that attracts a large number of individuals.

<sup>29</sup>Subsidy withdrawal hits sales of electric vehicles, [http://www.business-standard.com/article/companies/subsidy-withdrawal-hits-sales-of-electric-vehicles-112061800043\\_1.html](http://www.business-standard.com/article/companies/subsidy-withdrawal-hits-sales-of-electric-vehicles-112061800043_1.html), 18 June 2012

<sup>30</sup> Communication with stakeholder, January 2013

This included:<sup>31</sup>

1. There is limited understanding of xEV technologies amongst customers;
2. Consumers are willing to pay a premium of 10-20% for HEVs justified by their lower operating costs, but the premium should be recoverable in 2-3 years;
3. There was a preference for HEVs followed by PHEVs and BEVs. People seemed to be comfortable with driving a more familiar car with an ICE as backup rather than a full electric vehicle, especially as accessing charging points near to where people park their cars is a difficulty.
4. Charging infrastructure is of concern to a lot of potential customers;
5. Finally, and interestingly, climate concerns were not a large driver for purchasing an xEV.

Among the various vehicle segments identified the easiest uptake of electrification would be buses, then 2 wheelers followed by four wheelers and three wheelers (rickshaws). Projections estimate that 4 wheel xEV uptake in 2020 could be in the vicinity of 1.6 – 1.7 million units, however to make this happen may require a mandate to government departments to procure EVs, though this has not been finalised. To have any chance of reaching targets will need various components of the EV ecosystem to begin to quickly act in concert.

Vehicle seg./ country		2W	4W Range		Buses	Total Range	
<b>India xEV projections 2020</b>	<b>Numbers</b>	<b>4.8</b>	<b>1.6</b>	<b>1.7</b>	<b>0.002</b>	<b>5</b>	<b>7</b>
penetration of xEV India	%	15.0%	17.8%	18.9%	-	14-16%	
Total vehicle Sales India	<b>Numbers</b>	32	9	9	-	43	
<b>Global xEV projections 2020</b>	<b>Numbers</b>	<b>27</b>	<b>5</b>	<b>13</b>	<b>0.12</b>	<b>32.12</b>	<b>40.12</b>
Global penetration of xEV	%	35.5%	7%	19%	20%		
Total vehicles 2020	<b>Numbers</b>	76	70	70	0.57		
India Share as per above	%	17.8%	12.8% - 30%		-		

Figure 2-3: Indian and global xEV demand projections for 2020 (millions)

Source: NEMMP

<sup>31</sup> Department of Heavy Industry and Public Enterprises, Ministry of Heavy Industries and National Electric Mobility Mission Plan 2020

Vehicle Segment	Two Wheelers	Three Wheelers	Four Wheelers	Buses	LCVs
Demand (2020)	4.8 million	20,000-30,000	1.4-1.6 million	2600-3000	30,000-50,000
Assessment of mandates required	Sufficient Demand, no mandates required	Insufficient Demand, similarity with 2W will drive localization; free additional permits will be useful.	Insufficient Demand, mandate like govt. vehicle fleet procurement may be required.	Insufficient Demand, mandate like procurement by STUs would be required coupled with pilot projects.	Insufficient Demand, City fleet could be mandated to be xEV starting 2015.

Figure 2-4 Demand Assurance measures – vehicle segment-wise assessment

Source: NEMMP

As noted, in some segments a demand assurance measure (such as State Transport Undertakings – STUs) may be needed to create stable demand. An effective demand incentive scheme, as outlined in the mission document will comprise:

1. Level of incentive
2. Vehicle parameters (battery size, technology, minimum vehicle performance criterion)
3. Time and volume phasing (volume-based, phase-out plans)
4. Localisation (local value addition, annual increase conditions)

The NEMMP also proposed incentive levels for 4 wheelers, with details to be finalized through the NEMMP Demand and Supply Working Group \*

Table 2-3 Suggested incentive levels

EV Type	Proposed Subsidy (Rs)*	Approximate USD equivalent amount
Mild HEVs (0.5-1kWh)	25,000	472
Full HEVs (1-2.5kWh)	50,000	944
PHEVs (2.5-10kWh)	100,000	1,888
BEVs (>10kWh)	100,000 (low performance)	1,888
	150,000 (high performance)	2,832

\*At these levels the paper suggests that subsidies could be offered to 200, 000 vehicles each year for 5 years.

*Supply side incentives (including manufacturing)*

As mentioned, the government wishes to develop a vibrant electric vehicle ecosystem. To do this will require support to ensure that there is a sustainable customer base and that the prices of vehicle are not prohibitively expensive. The NEMMP envisages lower acquisition costs over time through several key levers:

1. Economies of scale associated with higher volumes;
2. Lower costs through technological developments;
3. Greater localization.

To ensure that manufacturing develops in a considered manner, the government has set out a broad roadmap for development of domestic manufacturing capabilities starting with domestic assembly in the next 1-4 years, progressing to indigenized products, locally developed products and technologies for India, and finally manufacturing for export in 10 years. (Figure 2-5, below)

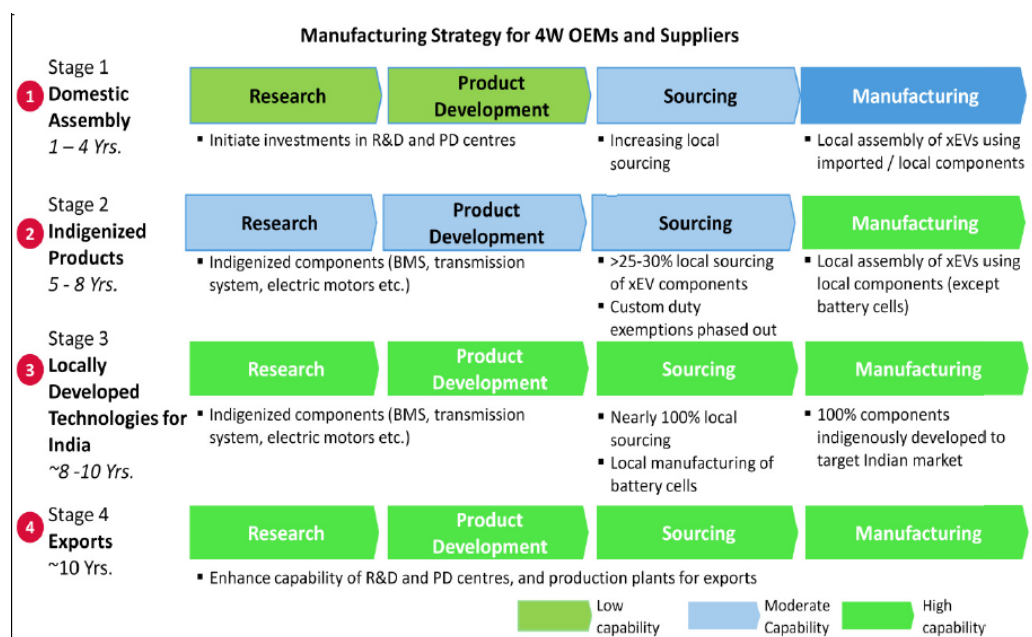


Figure 2-5 Phased approach to encouraging manufacturing of xEV four wheelers

Source: NEMMP

#### 2.4.4 Legitimation and Resource Mobilisation

Standards, policies and changing consumer demographics (more younger potentially environmentally conscious individuals) are helping to build confidence in a potential future market for xEVs. Yet, a number of challenges remain as government seeks to increase the number of electric vehicles in India.

Unless the costs and convenience factors that people associate with an ICE over an xEV can be addressed then there will be issues in wider scale adoptions of electric vehicles. Broad awareness building is required to ensure that customers understand the benefits of xEVs, be it personal passenger vehicles or buses. There is also a need to ensure that certainty comes into the market for EVs. At the consumer level, EVs will be a push product for some time.

Government and industry both play important roles in helping increase the legitimacy of xEVs. The first steps of this have been undertaken through a considered approach to the development of the NEMMP. This needs to continue through the implementation of the policy, which will need to include significant barriers to consumer uptake. Stakeholders interviewed recognize that customers may initially be more comfortable with HEVs, which have the added comfort of a combustion engine and no need to plug-in, moving along the chain to more complex PHEVs and BEVs, which require greater access to charging infrastructure.



The backing from Government for development of the NEMMP brings some confidence to industry players. This has been strengthened even further by good cooperation between government departments as well as between government and industry. But the challenge, as with any policy, is ensuring that the momentum developed through the policy development process is maintained throughout implementation.

There has been a confluence of rising fuel prices, government focus on fuel security, and willing participants. The NEMMP has been possible through strong collaboration, but it has also been due, in part, to several government and non-government individuals being at the right place at the right time to drive initiatives. Due to the nature of public service in India, government officials will often be rotated through roles. This brings a challenge to ensuring momentum to initiatives as it is often difficult to institutionalize an approach once the driving individual moves on. It is vital to the success of xEVs in India that the current momentum be seized, the policy signed-off and implementation begin.

At the end of February, the 2013-2014 budget will be released. It is hoped that a budgetary allocation of around 700 Crore (USD 132 million) will be made for R&D and around 10,500-10,700 crore (approximately USD 2 billion) in support for demand side incentives. This will help car makers push new generation vehicles into the market.

## **2.5 Conclusions**

The automotive sector is important to India. Linkages through the economy mean that the direct and indirect benefits of a robust car industry are spread relatively broadly. This is further augmented by the desire to develop India as a vehicle manufacturing hub. This should mean that the industry also continues to receive attention and support from the Government to achieve its growth potential.

However, this potential will need to be met in the context of increasing fuel costs, a government concerned about climate change and very focused on fuel security. These form the basic drivers to develop an xEV market in India.

The xEV market in India is at a formative stage and needs careful nurturing by government to be a success. This will be in the form of clearly defined policy, well-structured incentives, and clear communications to stakeholders across the spectrum, from manufacturers to customers. Positive signs exist showing that a pragmatic approach is being taken to develop the electric mobility ecosystem. The NEMMP reflects on past experiences and is open to international experiences to be leveraged into India. For example, a move to localized manufacturing activity over a period of 10 years is a realistic, pragmatic approach rather than a silver bullet.

Legitimacy of the EV market and realization of its potential will only begin to develop when incentives, R&D, consumer awareness and uptake and supply begin to act in concert. It is imperative that the National Automotive Board be established and begins to take control of the activities of the NEMMP and ensure that the coordinated and collaborative approach that started through the policy planning process continues into implementation and market development.

Confidence will need to be built to ensure that there will be policy and regulatory certainty, especially with regard to both demand and supply side incentives. Effectively the NEMMP needs to set in motion activities that de-risk perceptions of the electric vehicle market – both for consumers and suppliers.

## 3 China

### 3.1 Introduction

Will the breakthrough for vehicles not powered by petrol come in China? That remains to be seen, but the Chinese government has high hopes that the country in a few years can become a leading global player. The Chinese' visions for new energy vehicles incorporates the whole production chain from R&D to large scale production, implementation of the vehicles and export.

There are several reasons and converging trends behind China's keen interest in pushing non-traditionally powered transport vehicles. A first one is to reduce overall oil consumption. In a country where cars, buses and trucks in a short time have increased in numbers from rare to causing traffic congestions – and the numbers are still rapidly increasing – oil demand has risen sharply in recent years.<sup>32</sup> It has been pointed out that if China were to achieve the same level of per capita vehicle penetration as the USA its demand for oil would exceed present-day total global production.<sup>33</sup>

A second reason is energy security: over the years China has been forced to import an ever-increasing share of its oil consumption, often originating in unstable countries and transported over waters perceived as non-secure. Achieving as high a percentage as possible of the vehicle fleet driven by other means than petrol would be an advantage from a national energy security perspective point of view.

Thirdly, the 12th Five Year Plan identifies new energy vehicles as one of seven “future strategic sectors”. Central to the 12th Five Year Plan is to change China's development model, which means moving the economy up the value chain; from production of simple products to advanced manufacturing and innovation. One reason why China has chosen new energy vehicles as one of seven key sectors to transform into an innovative high-tech export country was the perception that the country would need 3-5 years to reach the technology front, compared with 20 years to catch up with the advanced manufacturers of traditional combustion engines.

A fourth motive is to improve the air quality, especially in the Chinese mega-cities. Even though coal still makes up a large part of China's energy mix, a transformation to hybrid and electric vehicles would improve air quality in the cities around the country, where the fast-growing number of vehicles on the roads has made the air situation even worse. Perhaps more important in this context is increasing public dissatisfaction with environmental problems, which has begun to create political unrest, something the central government wants to avoid at all costs.

For these reasons China has decided to push what is referred to as *New Energy Vehicles* (NEV). The official Chinese definition of new energy vehicles is based on five categories: "Pure" electric vehicles (BEV) , hybrids (HEV), fuel cell vehicles (FCV), hydrogen cars and vehicles powered by other energy sources (petrol, ethanol, etc). This report, when not specifically mentioned, refers to electric and hybrid vehicles since according to the Chinese government they make up the prioritized technologies for the development of new energy vehicles. For HEVs the preferred technology is plug-in hybrid vehicles (PHEV).

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<sup>32</sup> Ulf Andreasson & Markus Lundgren, *Personbilar i Kina. Marknad, produktion och politik* (2009).

<sup>33</sup> "Recharging China's electric vehicle aspirations - A perspective on revitalizing China's electric vehicle industry", *McKinsey & Company report* (April 2012).

### 3.1.1 Historical background

On one hand, China's focus on electric and hybrid vehicles is a relatively new phenomenon. In the 10th Five Year Plan (2001-05) one can identify an emerging focus on four-wheeled vehicles powered by energy sources other than petrol. The 11th Five Year Plan (2006-2010) claimed China will encourage the development of vehicles powered by "new types" of fuel. The national plan for mid- and long-term scientific and technological development, published in 2006, mentions the same area as prioritized. The more accelerated development began around 2007, when the National Development and Reform Commission (NDRC) pointed out new electric vehicles as an area of national strategic interest that may be subject to special attention from the central government. In the present 12th five-year plan, which is valid until 2015, new energy vehicles have an even more prominent role and are now placed at the centre of the Chinese development strategies.<sup>34</sup>

On the other hand, electric vehicles already have a long history in China, which might even be the country in the world where electric vehicles have been most successful. In the mid-1980s Deng Xiaoping pointed to seven technology sectors which would function as spearheads for change in China. One of these was the energy sector. Among other measures, the government worked out a special programme for fuel cell development, thus being able to transport large amounts of labour to the new factories without using petrol. In practice, this meant production of large numbers of electric mopeds. There are currently over 150 million electric two-wheelers on the Chinese roads. This has a direct link to this report through battery manufacturing being an area where China has already gained a substantial amount of experience.

### 3.1.2 Future targets and related goals

The current Five Year Plan sets clear goals for the implementation of new energy vehicles in China. In 2015, production and market should reach 500,000 (accumulated). By 2020, China aims to have five million electric- and hybrid vehicles on the roads (accumulated) and an annual production capacity of two million vehicles. At first glance the numbers might seem ambitious, but they are actually lower than earlier targets. Twice as high ambitions were mentioned by the Ministry of Science and Technology (MOST) as late as autumn 2010. Going further back, in 2009 the MIIT published a number of policies designed to create an industry for BEVs and HEVs in China. According to the ambitions, MIIT expected that in 2012 the country would produce half a million new energy vehicles which would then have been equivalent to 5% of total domestic production. The ambitions were considered unrealistic and already the following year down-played by the State Council.<sup>35</sup> As we shall see, the revised numbers are still far from the targets.

In April 2012, the Chinese government decided that BEVs are the long-term preferred technology but HEVs, and especially PHEVs, should function as a transformation technology. However, there is still some attention being paid to other types of new energy vehicles, mainly FCV. But recently China also decided to start up 700 pilot ethanol production sites to be used for transport means.

There are also more detailed goals. The fuel consumption (on average) for cars on Chinese roads should be reduced from (current) 0.77 l/10 km to 0.69 by 2015. For new energy vehicles the target will be 0.59 l/10 km. In 2020 it is expressed that the average consumption will be reduced to 0.5 l/10 km. For new energy vehicles it should be 0.45 l/10 km.

<sup>34</sup> Ulf Andreasson, *El- och hybridbilar i Kina. Planer, aktörer och policy (2012)*.

<sup>35</sup> Ulrike Tagscherer, *Electric Mobility in China - A Policy Review. Fraunhofer ISI Discussion Papers (2012)*.

For infrastructure MOST has set a target for the construction of more than 400,000 charging piles by 2015.

It should be pointed out that in a wider perspective the goals for the sector are in line with other important overarching goals for the Chinese economy. In the current five-year plan the Chinese government has set a target to improve energy efficiency by 16%, and also to improve carbon intensity by 17%. Furthermore, the contribution of the strategic sectors to GDP, where New Energy Vehicles are included as one of seven sectors, should increase from 5% (2010) to 8% by 2015 and 15% by 2020.

### 3.1.3 Main actors and networks

The actors active in the Chinese electric and hybrid vehicle innovation system are primarily public.<sup>36</sup> In China today the state still owns the commanding heights of the economy. That is especially true of developing industrial sectors like electric and hybrid vehicles. More concretely, the Chinese state has five main roles in the EV innovation system:

- Pointing out priorities
- Developing regulations, policies and standards
- Providing investments and funding
- Creating knowledge
- Creating demand

As always in China, one main actor is the NDRC, the most powerful of China's ministries and responsible, among other things, for long-term economic development, deciding which sectors should receive priority status and which projects should be supported by central funds. For example it was the NDRC that determined the seven strategic sectors mentioned earlier. Furthermore, the NDRC contains the main energy governmental policy organizations.

Another key actor is the Ministry of Science and Technology (MOST) – responsible for large-scale R&D programme. One of the most important players in the field is the Ministry of Industry and Information Technology (MIIT). It has main responsibility for the industrial development of new energy vehicles. The Ministry of Finance (MOF) is also deeply involved in the policy process for HEVs, mainly in the form of subsidies.

The actual creators of knowledge are predominantly governmental research organizations, public universities, and state-owned enterprises (SOEs) (battery producers, car manufacturers, etc). These actors often collaborate with each other in joint labs and research institutes.

Given the importance of the SOEs, China's State-owned Assets Supervision and Administration Commission of the State Council (SASAC), the organization (having ministerial status) responsible for the largest Chinese state-owned companies, including those in the automotive, battery, electronics, etc. is of high relevance. SASAC also controls the flow of investments to the SOEs and tries to make sure that the economy runs along the lines laid down in the five-year plan. In 2009 SASAC formed a special committee, the State-owned Enterprise Electric Vehicle Industry Alliance (SEVIA) including 16 SOEs involved in EV

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<sup>36</sup> Ari Kokko & Yingqi Liu, "Governance of new energy vehicle technology in China. The case of hybrid/electric vehicles", in Måns Nilsson; Karl Hillman; Annika Rickne; Thomas Magnusson (ed.), *Paving the Road to Sustainable Transport: Governance and Innovation in Low-Carbon Vehicles* (2012).

production in order to smoothly implement the government's policies. The networks also provide feedback to the government on policy issues related to new energy vehicles.

The two major national power grid companies in China are heavily involved in building up an infrastructure around PHEVs. By far the bigger of the two, the State Grid Corp. of China (SGCC) – owning some 80% of the Chinese power grid – has unofficially claimed that by 2030 it wants to control some 50% of the world market for electric and hybrid vehicle infrastructure.<sup>37</sup> Furthermore, a recently spotted trend is that several of the national oil companies have begun working on the development of an appropriate infrastructure for electric and hybrid cars – in some cases together with the power grid companies.<sup>38</sup>

Other important public entities are the provincial and local authorities. Chinese car-makers often have strong regional or local ties (the companies are often owned by the provinces), which means that the authorities are eager to protect and boost their development. The provincial and local governments often support joint research between car manufacturers and universities within the province or city. The provinces' total R&D expenditures exceed those of the central government. In many ways it is more accurate to see China as a country with many different innovation systems existing on different levels. Many Chinese provinces and cities want to be the centre for the development of new energy vehicles in China.

The cities play a dual role by also having the main responsibility for implementing the technology. This is specifically true for 25 that have been designated pilot cities (for public transportation) by the government and a few additional cities pointed out as pilot cities for private HEVs.

There also some non-governmental organizations and private companies of interest: The two main exceptions from the dominance of SOEs are the two private car manufacturers BYD and Geely, where BYD in particular has attracted attention. Before becoming a car manufacturer BYD had a background in battery production.

There are also foreign car manufacturers participating in the Chinese development, mainly in JV with Chinese partners. But the foreign manufacturers also clearly have concerns about the weak IPR protection in China and are hesitant to fully engage in technology transfer.<sup>39</sup>

Another organization of interest is the China Electric Vehicle Association (CEVA). CEVA was founded in 2004 and describes itself as a non-governmental organization made up of industry stakeholders in the electric vehicle sector, public institutions and experts in the field. CEVA claims to be a bridge between government and industry and aims to (financially and technically) develop the electric vehicle industry in China. There is also an International Alliance for New Energy Vehicles, where both Chinese and international players participate. A related actor is the SAE, the Society for Automotive Engineers, which is a kind of network of engineers and companies in the automotive industry. The SAE also has a special department working exclusively with electric and hybrid vehicles. The SAE has also functioned as a sort of think tank and, on top of that, has also developed some standards in the field (in China there are often several standards in the same technology sector).

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<sup>37</sup> Picked up in an interview with Martin Schoenbauer, working for DOE at the US Embassy to China, 2013-01-16.

<sup>38</sup> Kokko & Liu (2012).

<sup>39</sup> "Recharging China's electric vehicle aspirations - A perspective on revitalizing China's electric vehicle industry", McKinsey & Company report (April 2012).

In conclusion, the actors involved in the Technology Innovation System for new energy vehicles in China are many, indicating the system's complexity. As pointed out earlier, most of the actors are public in one way or another. However, private companies in China are known to closely follow suit in priorities pointed out by the central government. For example in a situation where a certain technology is pushed by the central government, the difference between a private and a state-owned company is considerably smaller compared to a Western context. (One can argue similarly for NGOs; in China they are always in some kind of relationship with the state structure and restricted from acting independently.)

Although one might believe that since most actors are either public or act according to the Chinese government they should act in a unified matter. That is far from certain. China is known for being a highly competitive society, where different actors are involved in strong competition with other actors – primarily with other actors at the same level, i.e. between different ministries, between provinces and cities, and between different SOEs. This is a topic that will be expanded further later in the report.

### 3.2 Functional pattern of HEVs in China

This section describes the governance structure for electrification of the vehicle fleet in China, based on the innovation system functions identified in the TIS framework.<sup>40</sup>

#### 3.2.1 Development, direction and diffusion of knowledge

As mentioned, China has since the 1980s developed an expertise in the battery area by producing electric vehicles on two wheels. In the early 2000s, the Chinese government began to see bigger (four wheel) new energy vehicles as an area for special attention, which led to some initial R&D investments. Government investments in R&D therefore have a longer history than investments in industrial manufacturing (besides two wheeled vehicles) of electric and hybrid vehicles. During the 10th and 11th five-year plans (2000-10) governmental funds allocated means through two projects, including the 863 programme, which since 1986 added funds for applied research in China with the intention of (among other things) making the country less dependent on foreign technology.

The current key governmental tools for steering knowledge development for the new energy vehicle innovation system are research funds, like the previously mentioned MOST's 863 programme, focusing on high-tech projects with strategic importance. There are also other governmental funds (including from MOST) which are being applied to spearhead electric vehicle development. The National Science Foundation (NSF) for example distributes funding for development in this area, mainly to the universities. The funding provided by the NSF, however, is significantly lower than that of the 863 project. There is also a new governmental fund (probably linked to the Ministry of Finance) for Energy Automotive Industry Technology Innovation and Engineering Support. There is also funding available from SASAC for electric vehicle projects.

MOST has to support R&D development for electric vehicles in a special five-year plan.<sup>41</sup> Major parts of the plan are not publicly available.<sup>42</sup> However, it has previously been decided to divide the EV R&D into three so-called verticals and three horizontals. The three verticals are fuel cell technology, pure electric vehicles and hybrid vehicles and the

<sup>40</sup> For more info on the TIS framework, see Bergek et al (2008) *Analyzing the functional dynamics of technological innovation systems: A scheme of analysis*, 2008, *Research Policy*, (37), 3, 407-429.

<sup>41</sup> *Science and Technology Daily* (on line)

<sup>42</sup> MOST has declined interviews for this report.

three horizontals are engine, drive and battery.<sup>43</sup> Discussions between the MIIT and MOST in 2012 resulted in a decision that in the long term pure electric vehicles should be the main technology and (plug-in) hybrids would serve as a transition technology.<sup>44</sup>

As pointed out, the bulk of new energy vehicle related R&D and innovation in China is carried out by public organizations such as governmental research organizations, public universities (often in collaboration with companies), and (with a few exceptions) SOEs. According to some government-related analyses, BYD, Cherry, Dongfeng, Changan, Shanghai Auto Group and First Auto have so far been the most successful companies in R&D.<sup>45</sup> Nevertheless, several of the car manufacturers, especially BYD, have been forced to back down from earlier bold statements for plans to commercialize and export vehicles due to technology proving to be harder to master than anticipated.<sup>46</sup>

When analysing technology development in China one always needs consider the risk of Chinese companies copying what has been achieved by other companies or research institutes in other countries – thus violating international patent laws. Such accusations have also been heard regarding EV technology development in China. For example, BYD has been accused of copying Japanese battery technology – acquitted however in the Chinese courts.<sup>47</sup> There is a frequently observed pattern of foreign high-tech companies accusing Chinese companies of IPR infringement but not being able to prove their point in the Chinese courts. If convicted, the penalties are often mild.<sup>48</sup>

### 3.2.2 10 cities, 1,000 vehicles

Knowledge of new energy vehicles is not only created in Chinese research institutes and labs but also *in situ*. In 2009 MOST, MOF, NDRC and MIIT jointly created the "10 cities, 1,000 vehicles" (TCTV) project with the ambition to develop industry and R&D and pave the way for further implementation of electric and hybrid public transport. From the original ten cities the project has expanded to now incorporate 25. There is also a parallel project (but involving fewer cities) for private use of electric and hybrid vehicles. In both projects the central government sets general framework policies that include national subsidies. Together with other relevant organizations the local authorities then implement the national policies but also have the possibility to add on additional measures, create custom policies and supportive structures (e.g. clusters) and add additional subsidies. These types of demonstration projects are very common in China for implementing and developing new technology.<sup>49</sup>

Many of the cities in the two projects coincide with places where automotive manufacturing already exists or that have a cluster around automotive manufacturing and/or battery development. In the cities involved in the projects, local stakeholders, primarily companies in the EV cluster but also research institutes, have regular meetings with local authorities

<sup>43</sup> Andreasso, (2012).

<sup>44</sup> *Ibid.*

<sup>45</sup> According to a report from 2012 by a Chinese the government consultant firm; China Investment Consulting Net.

<sup>46</sup> See *Financial Times* 2011-08-22.

<sup>47</sup> [http://www.businessweek.com/innovate/NussbaumOnDesign/archives/2010/02/the\\_truth\\_behind\\_chinas\\_byd\\_car\\_company--and\\_warren\\_buffets\\_investment.html](http://www.businessweek.com/innovate/NussbaumOnDesign/archives/2010/02/the_truth_behind_chinas_byd_car_company--and_warren_buffets_investment.html)

<sup>48</sup> For further discussion see Kristina Sepetys & Alan Cox, *Intellectual Property Rights Protection in China: Trends in Litigation and Economic Damages* (2009).

<sup>49</sup> It is also common to use major international events to push a certain technology; e.g. the Olympic Games in Beijing and the Shanghai Expo were two such international large-scale events that were used as a means to push EVs in China.

how to jointly develop the sector. As mentioned previously, there is a strong local and provincial dimension in Chinese new energy vehicle development.

One point of concern for the Chinese government – for EV development as for many other sectors – is the swing between on the one hand coordinating the knowledge development and on the other leaving it to the different clusters at regional/local level to come up with the best solutions. As an MIIT representative pointed out in an interview, regional and local interest in the development of electric vehicles has almost over shadowed national interest.<sup>50</sup> It is clear that the Chinese government is struggling to find a balance between developing HEVs with a regional cluster perspective and pushing development in a national perspective.

### 3.2.3 Entrepreneurial experimentation

The Chinese car industry is highly fragmented with more than 200 different manufacturers, mainly state-owned. Many of these companies have in one way or another been involved in the development of new energy vehicles. Some 135 different models have been recognized as official new energy vehicles, developed by at least 27 different manufacturers.<sup>51</sup> Out of a just over 1,100 vehicle models that were shown at the Beijing International Automotive Exhibition 2012, about 88, or about 8%, were new energy vehicles.<sup>52</sup>

However, a relatively small number of the car manufacturers are *serious* actors in the development of electric and hybrid vehicles in China. In 2011 about 8,000 new energy vehicles were produced in China. The largest producers were Cherry (3,000), Jianghuai (1,250), BYD (1,035) and Shanghai Auto (500).<sup>53</sup> Approximately two thirds of these were BEVs and the remainder HEVs (most likely all were PHEVs). By way of comparison, approximately 18 million new passenger cars are sold annually on the Chinese market. New energy vehicles thereby merely make up approx. 0.4 per mil of the car market.<sup>54</sup> The total accumulated number of new energy vehicles in China by the end of the same year was some 16,500. By the end of 2012, the number had increased to 30,000.<sup>55</sup> As can be understood, China is still far from its stated objectives for the industrialization of new energy vehicle production.

The heavy reliance on SOEs risks substantially hampering entrepreneurial activities. It has been pointed out that Chinese SOEs in general have weak innovation capacity.<sup>56</sup> (It is often pointed out that innovation capacity in the Chinese society in general is low). On the other hand, the Chinese innovation system has some special characteristics which can play an important role in the development of electric and hybrid vehicle technology. Chinese companies are generally more open to market introduction at an early stage of production development, using consumer feedback to develop the succeeding product generations. Companies in developed countries are in general more hesitant to market introduction at an early stage, afraid of negative reactions from consumers. In China, there is a greater acceptance of failure if the experiment is carried out in the interest of moving toward the government's goals. New energy vehicles are a good example of this as the country has

<sup>50</sup> Andreasson (2012).

<sup>51</sup> Andreasson (2012).

<sup>52</sup> 2012 Beijing International Automotive Exhibition, *Xinhua News*, 2012-04-24

<sup>53</sup> *China Investment Consulting Net*, report (2012).

<sup>54</sup> Andreasson (2012).

<sup>55</sup> According to *Sina Auto* (2013-01-17). Figures come from an advisor to China Vehicle Industry Association.

<sup>56</sup> Martin Wikström et al, *Nuläge och trender kring offentliga innovations- och forskningsansatningar i USA, Japan, Sydkorea, Kina, Nederländerna, Brasilien och Indien*, (2012).



taken off in a certain direction but is at the same time aware that it will not be perfect from the beginning.<sup>57</sup>

The Chinese government strives to create electric- and hybrid vehicle clusters ("national teams") in cities and provinces like Changchun, Shanghai, Wuhan, Chongqing, Beijing, Guangdong and Anhui (among others). The cities are to a high degree identical with the cities involved in the EV demonstration projects. One important reason for choosing the cities was in fact the existence of car manufacturers in the city or its proximity. (In addition, it plans to create battery clusters in Tianjin, Shenzhen and Hangzhou.) By 2020, according to plans, 90% of the industry will be concentrated in these areas. According to the ambitions, the Chinese electric- and hybrid vehicle industry will eventually be restructured and consolidated into 2-3 major manufacturing groups in addition to 1-2 medium-size producers and 3-5 small ones.

It should, however, be noted that the Chinese government has had similar consolidation plans for the entire domestic car industry for a long time, but which have failed partly because of strong local and regional resistance to such plans.<sup>58</sup> No city or province is willing to give up their car manufacturer in the name of a national need to restructure industry restructuring – even though they agree that such a change is needed.

### 3.2.4 Market formation

The market for new energy vehicles is still very small compared to traditional fuel vehicles. It is not even driven by increasing demand from environmentally concerned Chinese consumers but by public actors, mainly authorities in the cities appointed as demonstration and pilot cities. They mainly buy vehicles for public use (buses and taxis) produced by the local car manufacturer. The creation of public fleets as the primary objective sets China apart from many other countries where private consumers – especially with environmental concerns – are the most likely to emerge as first buyers of electric- and hybrid vehicles.

The government subsidizes the introduction of new energy vehicles with a maximum subsidy of RMB 60,000 (similar in SEK) for BEVs and RMB 50,000 for PHEVs. For buses the subsidies depend on the deployed technology but can be at most RMB 500,000. The amount of the subsidy is finally decided according to the efficiency of the technology. The subsidies have mainly been used to purchase taxis and buses. In addition, local authorities (involved in the special project to spur private interest) may provide further a subsidy of the same amount as the national subsidy.

Other economic incentives have been introduced, for example elimination of vehicle tax for new energy vehicles. Parallel to the introduction of economic incentives for new energy vehicles, the taxes on traditional passenger cars have been raised. Already in 2008 the tax was raised for cars with engine capacity of three litres. In January 2012 additional taxes were added for cars with an engine capacity of 2-2.5 litres and significantly higher for those with even bigger engines.

On top of the monetary benefits, other local policies have more recently been introduced. For instance, during autumn 2011 Beijing declared electric- and hybrid vehicles exempt from the rule where the car's licence plate dictates which days you may (or may not) drive the car into the city. For new energy cars it is possible to enter the city every day of the week. A new policy was recently introduced in some major Chinese cities, e.g. Beijing, Shanghai and Guangzhou, stating that if you buy an electric- or hybrid vehicle you do not

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<sup>57</sup> McKinsey Quarterly, *Three Snapshots of Chinese Innovations* (February 2012).

<sup>58</sup> Andreasson & Lundgren (2009).

need to participate in the lottery for a registration plate that for example Beijing holds every month to limit the number of new cars on the city's roads, or the auction for new registration plates that Shanghai has introduced. In the case of the auctions in Shanghai, the present cost of a plate is around RMB 75,000 (January 2013, slightly more in SEK). One can consider bypassing the auction to be a way for the city to further increase subsidies, thereby adding to other subsidies.

So far the subsidies and policies have failed to stimulate any massive response, neither from the cities nor from private buyers. However, initiated actors seem to have high hopes for the latest policy initiatives where electric- and hybrid vehicles offer a chance to obtain a license plate more quickly and less expensively.

### 3.2.5 Legitimation

The initial Chinese analysis of China's new energy vehicle innovation system showed it to be lagging only some 3-5 years behind the global technology front but has lately been modified. According to researchers at the government's own think-tank, technology is still lagging behind compared to the level of the technologically most advanced countries. Worse so from a Chinese perspective, the gap seems to be widening. This also includes the different key components.<sup>59</sup> A chief engineer at one of the main producers of BEVs and PHEVs in China claims that the technology gap to the most advanced producers is actually probably closer to ten years.<sup>60</sup> The main reason for this increased gap is slow progress by Chinese actors and faster development by some key actors in other countries. But it has also been pointed out that bad technology decisions have been made which have severely affected development.<sup>61</sup>

The same can be argued for infrastructure; the roll-out plan for infrastructure to be implemented by State Grid and Southern Power Grid is far from its targets.<sup>62</sup> Other more horizontal aspects also not developing according to initial plans are standards as well as clear policies.<sup>63</sup>

More precisely, immature battery technology, underdeveloped supply chains and lack of infrastructure are elements that prevent the Chinese electric and hybrid vehicle industry from taking off. Chinese car manufacturers, as well as other actors in the innovation system, are not progressing as fast as anticipated by the Chinese government. At the same time the lack of IPR protection in China results in foreign manufacturers being sceptical to transferring extensive knowledge in the field to China – which the Chinese government strongly pushes the foreign firms to do.<sup>64</sup>

There have been several complaints from Chinese cities that electric vehicle technology is still not mature enough to be implemented according to plans set at national level.<sup>65</sup> This

<sup>59</sup> Xiaoming Wang & Fushen Hou, 'The Status Quo of China's Electric Auto Industry', *China Development Review* 14:4, November 2012.

<sup>60</sup> Interview, BAIC Motor 2013-02-22.

<sup>61</sup> Wang & Hou (2012).

<sup>62</sup> Up to 2011 less than five percent of the 2015 target for the infrastructure roll out had been completed. "Recharging China's electric vehicle aspirations / A perspective on revitalizing China's electric vehicle industry", McKinsey & Company report (April 2012).

<sup>63</sup> For example there was a long debate whether BEV or PHEV should be the main focus for the Chinese development. In the end (April 2012) the Chinese government decided for the first with the latter as a transition technology, but the process delayed the development of the whole sector.

<sup>64</sup> *The Economist*, "Electric cars. Highly charged", 2011-06-30.

<sup>65</sup> See *Financial Times*, 2011-08-22. Furthermore, so far possibly no private HEV cars have been sold in Beijing in spite of the goal of 30 000 for 2012 set in 2010. *Caixin*, 2010-11-29.

relates of course partly to technical issues such as infrastructure and battery capacity – which are universal problems – but also to the failure rate, reliability and engineering ability of the Chinese electric vehicles falling short compared to foreign-produced ones. According to a chief engineer in Chengdu, the city’s hybrid buses face twice as high risk of experiencing problems compared to the buses driven by traditional engines. In addition, one special aspect that has raised public alarm in China is the risk of battery explosion; a couple of accidents have been highly debated, giving EVs in general a reputation of being an unsafe technology.<sup>66</sup> The attempts to introduce electric- and hybrid vehicles are also considerably more expensive compared to the alternatives, further hampering introduction. For example, in Chengdu, one of the cities in the TCTV project, EV buses are considered to be three times as expensive as the new natural gas driven buses (which are more energy-efficient and less polluting than petrol/diesel driven) that the city has also purchased. (The city of Chengdu is situated in Sichuan province, which is rich in natural gas, which makes natural gas a cheap alternative.)<sup>67</sup> One local official summarized the introduction of EV buses by stating that the advantages from the point of the city “are not very clear”.<sup>68</sup>

At the same time there has also been strong criticism of how the central government has organized implementation in general and the TCTV in particular. A governmental study on the matter concludes that there has been insufficient information to the cities and uncoordinated gathering of data from the projects.<sup>69</sup>

A report confirms that the TCTV project is lagging behind original plans. By late 2011 only 26-36% of the goals had so far actually been achieved.<sup>70</sup> In an interview with a main government representative (from the MIIT), he stated that there had been too many “false starts”, indicating that grasping and implementing the technology has not progressed as smoothly as the authorities had anticipated.

The Chinese government has lately criticized cities not implementing the vehicles according to the targets. Three of the main governmental ministries (MOF, MIIT, and MOST), after evaluating development of the introduction of electric and hybrid vehicles, released a joint statement saying that if any of the 25 cities involved in the TCTV are not motivated enough to introduce electric vehicles to a significant extent in their vehicle fleet, they will be replaced by other cities. Some of the under-achieving cities mentioned were Tangshan, Hohhot, Jinan and Chengdu.<sup>71</sup>

The doubts and hesitations have also hampered industrial development. BAIC’s production facility outside Beijing, according to the company itself the production centre for EVs in China with the highest production capacity, only used some 5% of its production capacity in 2012. In 2013, it hopes to increase production but still far from its capacity.<sup>72</sup>

However, not everything on China’s EV sky looks cloudy. The city of Shenzhen (close to Hong Kong) is often held up as the city in China where one can see an early breakthrough. The city, which is also one of the TCTV cities, has managed to introduce a substantial

<sup>66</sup> *This debate is partly due to the batteries in China are mainly lithium-ion phosphate based which are more prone to exploding compared to manganese acid lithium batteries, commonly used outside China*

<sup>67</sup> *Traditional gas driven buses are, according to the city’s own calculations, actually more expensive than the ones driven by natural gas - however still considerably cheaper than HE buses. Interview with Chengdu Bureau of Transport, 2012-11-21.*

<sup>68</sup> *Interview, Chengdu Bureau of Transport, 2012-11-21.*

<sup>69</sup> *Wang & Hou (2012).*

<sup>70</sup> *Huiming Gong, Michael O. Wang, Hewu Wang, “New Energy Vehicles in China: Policies, Demonstration, and Progress”.*

<sup>71</sup> *Economic Information Daily.*

<sup>72</sup> *According to visit to production site 2013-01-22.*

number of electric and hybrid vehicles, mainly taxis and buses but also some private vehicles, on the city's streets. Infrastructure has also expanded to support the growing EV fleet. Besides being one of the TCTV cities, the relative success of Shenzhen can be explained by it being home to car manufacturer BYD – by some considered the most innovative of the Chinese car manufacturers involved in developing BEVs and HEVs.<sup>73</sup> (Since before becoming a car manufacturer the company was originally started up as a battery producer its high ambitions do not come as a surprise). Also, in the city of Hangzhou a business model has been established that has received good reviews. Basically, instead of buying the battery people rent it.<sup>74</sup> In general, the cities that have their own car manufacturing have come further in implementation than the cities without a car production industry.

Furthermore, in one related area China has already produced something that could be described as a national success story. Low speed, small EVs seem to be taking third and fourth tier Chinese cities by storm. Their success is most likely linked to the smaller size of these cities making them a good match with battery capacity and the transport needs of the inhabitants - often elderly - in these cities. In the province of Shandong alone some 68,000 of these mini-EVs were sold in 2011 – and numbers are increasing rapidly.<sup>75</sup> These vehicles are however not included in the national targets for new energy vehicles.

### 3.2.6 Resources

It has been estimated that RMB 10-20 billion will be invested annually by the central government to support production and R&D in the sector.<sup>76</sup> One policy analyst claimed half of the funding will go to industrial development and R&D, 30% to demonstration projects and the remaining 20% to a special focus on hybrids.<sup>77</sup>

The investments by different companies – mainly SOEs – connected to the new energy vehicle innovation system will far exceed the funding from the central government. It is unclear how much their total contribution will be – which is always the case in China – but in general the distribution of investments in R&D between the government and the companies is about 30% from the former and 70% from the latter.<sup>78</sup>

As pointed out earlier, the car manufacturing companies receive funding in the form of subsidies from the national (and sometime also local) government for purchases of electric and hybrid vehicles. Also, the companies have (like some cities) faced governmental criticism for, in turn, complaining about insufficient government funding to close the technology gap to international actors in the electric and hybrid sector.<sup>79</sup> A governmental response pointed out that some of the fund-receiving companies have filed for bankruptcy - indicating that non serious actors are involved in the sector.

Funding from provincial and local authorities, especially those with local companies with stakes in BEV and HEV development, will also be substantial in the coming years. It has been pointed out that in general the Chinese provincial innovation systems are growing stronger and can compete with the national system. Among others things, the provinces

<sup>73</sup> Bram Buijs, "China and the Future of New Energy Technologies. Trends in Global Competition and Innovation". *Clingendael International Energy Programme* (2012).

<sup>74</sup> Wang & Hou (2012).

<sup>75</sup> Xiaoming Wang & Fushen Hou, 'The Status Quo of China's Electric Auto Industry', *China Development Review* 14:4, November 2012.

<sup>76</sup> *Science and Technology Daily* (on line), samt Kokko & Liu (2012).

<sup>77</sup> According to an electric vehicle conference in Wuhan HEV in April 2012.

<sup>78</sup> Wikström et al (2012)

<sup>79</sup> <http://www.chinasmartgrid.com.cn/> See article 2012-10-31. See also Nanfang Zhoumo, 2012-12-15.

today provide more funding for R&D&I than the national government.<sup>80</sup> One main incentive for provinces to invest in EVs is to attract producers of various kinds to the region.

Infrastructure investments are needed to create the conditions for the new energy vehicle market to take off. The aid the central government provides for this is mainly channelled through TCTV. In addition China's leading energy companies SGCC, China Southern Power Grid, Sinopec and China National Offshore Oil Company (CNOOC), plan to invest significantly in charging stations and other new energy vehicle-related infrastructure. The SGCC alone plans investments amounting to RMB 32.3 billion to build ten thousand charging stations by 2020. One driving factor for these energy giants to invest in EV infrastructure is the potential export market for the technology. In addition to China's energy giants now being seen to move into the EV infrastructure, some local governments have also offered first buyers of new energy cars to have charging stations built near their homes, thus creating an incentive for private buyers.

Another critical resource often mentioned is the lack of talent (skilled engineers) that can support the high national ambitions. Two cities (Beijing and Chengdu) interviewed for this report also stated lack of land to create charging stations as a problematic factor in introducing EVs on a large scale in the cities.

### **3.3 Conclusions**

China has set high goals for new energy vehicles. From the current national total of approx. 30,000 the government hopes to have half a million new energy vehicles on the roads in 2015 and five million by 2020. In 2020 China wants to have a production capacity of two million EVs. The long-term focus is on pure electric vehicles, but hybrids, mainly plug-in hybrids, acting as a transformation technology.

The ambitions are driven by several reasons and converging trends. Reducing dependence on oil is one major factor behind the Chinese government's push for new energy vehicles. Other important reasons are future export potential and better air quality in the biggest Chinese cities.

In many ways the electric and hybrid vehicle sector is typical of how the Chinese government develops a strategic sector. By combining subsidies of various kinds, forcing public actors to establish demand, pilot and demonstration projects, investments in R&D, strong involvement of state-owned enterprises etc., the Chinese government hope that they can turn electric and hybrid vehicles into a national success story. The special mix of ingredients makes up the features of China's new energy vehicles innovation system.

The central government is undoubtedly the driving force behind development. They are almost solely responsible for pointing out the main directions for the system as such and its components. The government is furthermore responsible for a large part of the investments, and they also force other public actors (cities) to create demand for electric and hybrid vehicles.

However, it is not a project solely driven by the central government. It also involves many other actors, most of them also public in one way or another. They all play different roles in developing the innovation system for electric and hybrid vehicles, but what is more typical for China is that the public actors often act in a fierce competitive environment – mainly with other public actors. They also have their own agendas and try to influence the development of New Energy Vehicles in China.

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<sup>80</sup> Wikström *et al* (2012).

Almost all informants agree that the government is over-enthusiastic and the targets too optimistic. Former PM Wen Jiabao has himself confirmed this in an article in the Chinese Communist Party Journal (Qiushi), recognizing that the challenges in the sector are many and some still remain to be addressed.<sup>81</sup> When it comes to policy, standards, technology development etc. China is still in the formation process; at the time of writing China can broadly be described as moving from a point where the car makers have developed a substantial number of concept models to initiate production on a larger scale. There is, in short, a wide gap between the targets set by the government and what the implementing actors think is realistic.

Perhaps the greatest gap can be found between central government, in charge of setting targets, and the local governments, responsible for implementation. In order to develop standards and policies, many pilot projects are being conducted around China. They seem to lack a strong national coordination and many of the decisions have been delayed. The cities are also the actors with main responsibility for creating (first) demand for new energy vehicles. The cities find the introduction too costly and the technology unreliable. To add to the local-national divide the local authorities are often driven by local rather than national incentives. For example, they often strongly support the local car manufacturer, even if they in principle agree with the central government that for the sake of the sector several producers should close or merge with other companies.

The big state-owned producers also seem doubtful. A general impression is that EV technology has proven to be much more complicated to master compared to initial Chinese calculations, and at the moment it is not even certain that the technology gap to the foremost EV nations, such as Japan, is closing but may even be widening. Furthermore, the impression is also that the SOEs don't think the government subsidies will be sufficient to make any substantial technological breakthrough – especially not within the time frame set by the central government. Policy development and standards are also lagging behind, leaving the Chinese car manufacturers in a “wait and see” situation.

Meanwhile, many foreign companies seem unwilling to transfer technology to China. Chinese car manufacturers have been suspected of copying what foreign companies have developed although this seems to be impossible to prove in a Chinese court of law. Nevertheless, the IPR question remains a big obstacle to foreign companies becoming more deeply involved in China's new energy vehicle innovation system.

Another sceptical group is private buyers, who will eventually take over demand for BEVs and HEVs when the public actors have bought their intended vehicle fleets. For buyers, price, infrastructure and security issues are factors that, despite attempts by the government to create incentives, hold back public interest. (Very recently, however, the introduction of new policies in some of the Chinese mega-cities to enable private buyers of new energy vehicles to bypass lottery procedures or auctions to obtain licence plates have shown signs of increasing interest in purchasing an electric or hybrid car.) Another crucial factor is the reputation BEV technology has gained in China of being inclined to explode.

**In conclusion**, there are some factors pointing towards lack of legitimacy as one important obstacle for China to introduce new energy vehicles on a grand scale. Even though the enthusiasm of the central government remains intact, there is a sense among many of the involved actors that the goals are not reachable – at least not in the time frame set by five year plans and other documents.

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<sup>81</sup> Buijs (2012).

But whereas some actors ask for more governmental funding and faster development of policies others say that the government should set more reasonable targets, for example by postponing the deadlines. Others argue for expanding the concept of new energy vehicles to also incorporate energy-efficient traditional petrol-driven cars.

On the other hand, since almost all present Chinese car buyers are buying their first car the concept of a car is still flexible to Chinese consumers. Together with the potential scale of the market and the enthusiasm of the government, they are the most important factor in support of a breakthrough eventually actually taking place in China.

## 4 Japan

### 4.1 Introduction

#### 4.1.1 Background

The Japanese market for electric vehicles is the most developed market in terms of vehicle as well as infrastructure deployment in the world as of today. Japan has the car manufacturers and battery manufacturers, has shown progress in infrastructure, and is the country with the highest number of electric vehicles (EVs) in Asia. The Japanese experiences with quick charging infrastructure, the early users' experience, and various government support measures are all relevant learning for policy makers and implementing stake-holders around the world.

Eco-efficient vehicles such as Electric Vehicles, Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV) are running on roads in Japan. The mass-produced Toyota Prius (HEV) has been sold on the domestic market since 1997, and the Mitsubishi i-MiEV (EV) and Nissan LEAF (EV) since 2010. In recent years, carmakers including those of Japan's special class of small cars (less than 660 cc capacity) have seen intensifying interest in even more fuel-efficient or electrified vehicles.

The Japanese government has been actively supporting a transition into an electrified vehicle fleet for several reasons. A large share of the nation's economy and economic growth is tied to the future success of the automotive industry. In Japan's portfolio of competitive industrial and research areas, we also find battery technology, the key technological artefact that will help leapfrog, or hinder, further development in the electrification of the vehicle fleet. The triple catastrophe of 11 March 2011 had a large impact on Japan. Supply chain strategies, prices of electricity and oil, and priority policy plans and visions were rethought. More so the Japanese people's perceptions towards electricity usage. The following rolling blackouts and detailed electricity forecast<sup>82</sup> changed people's mind-sets and behaviour on use of energy and electricity in Japan in a way not happened since the oil crises of the 1970s. Consumers and industry have managed to pull together to reduce electricity consumption, but at a hefty cost to its short-term national finances due to large increases in fossil fuel imports and possibly also to long-term competitiveness.

As for next generation vehicles as a tool for realizing a low emission society, there is a significant difference between EVs, HEVs, PHEVs and Fuel Cell Vehicles (FCVs) in terms of potential carbon dioxide reduction. HEVs can be compared with highly efficient conventional cars. The largest reductions can be made with PHEVs, EVs and FCVs. In the near future, EVs and PHEVs are considered to have the most important roles in the Japanese policy schemes.

The advancement of a new generation of electrified vehicles has for these reasons been put high on the government policy agenda. In Japanese policy documents, the concept of New Generation Vehicles encompasses all potential full or part replacements of a traditional petrol combustion engine.

The former government lead by the Democratic Party of Japan launched a new growth policy. The strategy's top-layer, "Comprehensive strategy for the rebirth of Japan"<sup>83</sup>, was

<sup>82</sup> TEPCO electricity forecast: <http://www.tepco.co.jp/en/forecast/html/index-e.html>

<sup>83</sup> NPU (2012) *Nihon saisei senryaku (Comprehensive strategy for the rebirth of Japan) National Policy Unit 2012* <http://www.npu.go.jp/saisei/images/pdf/RightNaviHonbun.pdf> (Japanese)



approved in July 2012. Four industrial areas were chosen, in which the domestic and overseas market demand were expected to increase in the future: 1.) “GREEN (energy & environment)”, 2.) “LIFE (health)”, 3.) “Agriculture, Forestry, and Fishery”, and 4.) “SMEs”. In the four growth areas, regulations were to be reviewed, and policy resources allocated on a priority basis. “GREEN” included several policy packages wherein “Green parts and materials as driving force of Green growth”, “Development of next-generation vehicles, Widespread usage of storage batteries”, and “Development of energy management systems (smart communities)” are directly or closely related to next generation vehicles. Policies by the new government as of December 2012 are not clear yet, but continued support for the previous policies seems evident.

#### 4.1.2 Future targets and related goals

The Ministry of Economy, Trade and Industry released its “Next-generation Vehicle Strategy 2010”<sup>84</sup> in April 2010. It described a wide variety of facts, technologies, roadmaps, and targets. The government’s diffusion targets by type of vehicle are shown below.

Table 4-1 Next-generation vehicle diffusion target. Source: Next-Generation Vehicle Plan 2010, METI<sup>85</sup>, Passenger vehicle sales results, JADA<sup>86</sup>

	2020	2030	2011
Conventional vehicles	50-80%	30-50%	72.8%
Next-generation vehicles	20-50%	50-70%	27.2%
Breakdown of next-generation vehicles			
HEV	20-30%	30-40%	26.5%
EV/PHEV	15-20%	20-30%	0.7%
FCV	0-1%	0-3%	0.0%
CDV	0-5%	5-10%	0.0%

Also in the current national growth strategy, several quantitative and qualitative goals related to next-generation vehicles for 2020 have been presented. These goals are related to vehicle deployments and infrastructure build-out as well as specific technologies such as batteries:

- Increase the percentage of next-generation vehicles in new car sales to 50% (Introduction of Fuel Cell Vehicle to the market for 2015)
- Installation of two million ordinary chargers and 5,000 quick chargers for EV and PHEV
- Achieve 50% (10 trillion yen approx.) market share for Japanese companies in the global storage batteries market (stationary and for automobile use included)
- Development of high-performance "rare-earth free" magnet, which has twice the magnetic force of current magnets and could be used for HEV/EV/PHEV/FCV

<sup>84</sup> METI (2010) *Next Generation Vehicle Strategy 2010* Ministry of Economy, Trade and Industry April 2010  
<http://www.meti.go.jp/press/20100412002/20100412002-3.pdf> (Japanese)  
<http://www.meti.go.jp/english/press/data/pdf/N-G-V2.pdf> (Outline in English)  
[http://www.meti.go.jp/english/press/data/20100412\\_02.html](http://www.meti.go.jp/english/press/data/20100412_02.html) (English announcement)

<sup>85</sup> *Ibid*

<sup>86</sup> JADA (2013) *Passenger vehicle sales, Statistics*, JAPAN AUTOMOBILE DEALERS ASSOCIATION,  
<http://www.jada.or.jp/contents/data/type/index04.php>

- Improvement of Lithium Ion battery performance for EV, which can drive twice longer distance than current ones. HEV/EV/PHEV should be used as electric sources for peak cut of electric power consumption, and for emergency situations.
- Installations of hydrogen stations for FCV

#### 4.1.3 Main actors, networks and institutions

A minimum group of actors relevant for examining the technological innovation system for electric vehicles should include government (national and local), vehicle manufacturers, battery and electric component suppliers, charging infrastructure providers, service providers, and consumers/users.

##### *Government (national and local)*

On a national level the Japanese ministries are working somewhat independently and overlappingly in the promotion of next generation vehicles, but with the same basic tools of financial incentives to the companies and private individuals, as well as research funding. In the Japanese governance structure the local governments have fairly substantial leeway in drafting their own policies, and have used this to various degrees.

The three main ministries relevant to understanding the system around next generation vehicles are the Ministry of Economy, Trade and Industry (METI), the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), and the Ministry of Environment (MoE), but also the local municipalities.

The Ministry of Economy, Trade and Industry (METI) promotes the automotive and related industries' role for next-generation vehicles. To realize the era of next-generation vehicles, METI carries out R&D programmes, for example, the RISING Battery Project, explained below, which is a joint R&D project by universities, companies, and national research institutes with public research funding through NEDO.

Especially worth mentioning is the METI's variety of financial subsidy schemes for both charging stations, especially in selected geographical areas, but also on a national level as well as the actual EV/PHEV-units.

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is mainly playing the role of promotion of next generation vehicles to the transport sectors also with tax exemption/reduction and subsidies. The MLIT also sets the safety regulations for these vehicles. The MLIT has had different subsidy schemes for low polluting vehicles, which include new generation vehicles for commercial use such as taxis, buses and trucks.

The Ministry of Environment (MoE) has also had different subsidies to promote low-emission vehicles for local governments and private firms to purchase vehicles, such as, EV/PHEV/HEV/FCV/natural gas vehicles, and their infrastructures.

Local municipalities have set several incentives for SMEs and individuals to purchase EV/PHEV/HEV/FCV/natural gas vehicles with tax exemption/reduction, low interest loan, and subsidies. In particular, local municipalities together with the central government promote ultra-compact EV in rural areas which are isolated from public transport network.

### Vehicle manufacturers

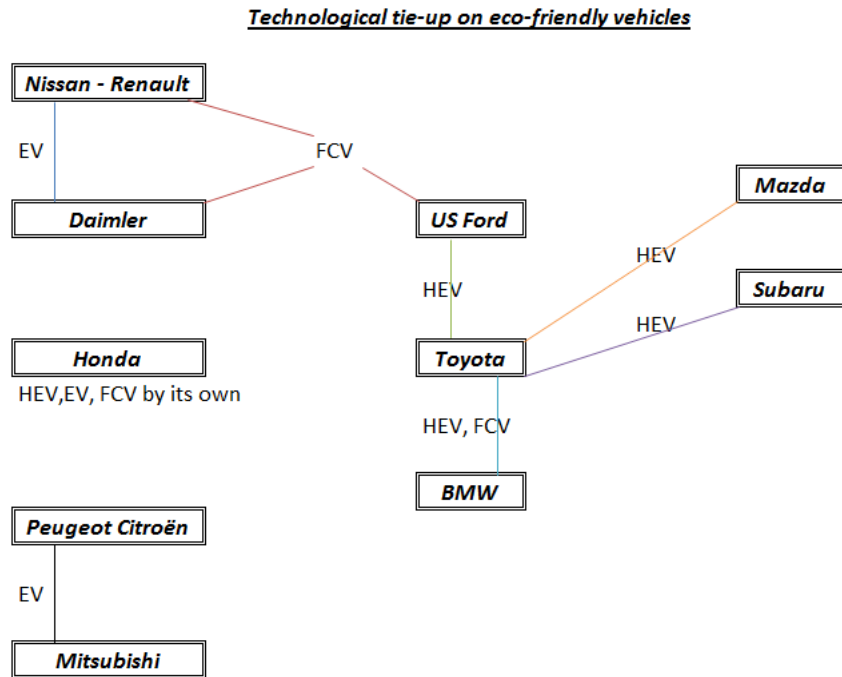


Figure 4-1 Technological tie-up on eco-friendly vehicles

Source: Nikkei (2013)<sup>87</sup>

A first observation when studying the actor map is the close tie-ups between practically all major car manufacturers worldwide, as can be seen from Figure 4-2.

Toyota, by far the biggest Japanese car manufacturer, has stated that they see more potential for PHEVs than EVs in the near future due to their short driving range (Toyota 2011). Toyota is also the company that invests most in R&D on FCVs, which they consider the ultimate environmentally friendly car. Nissan is the most aggressive company when it comes to EVs with the release of the EV Nissan Leaf in December 2010. Nissan also stands alone in the strategy of EV being the “first car”, while other manufacturers consider EV to be a second car for limited and specified use for short-distance driving. This is evident in the the Nissan Leaf being a five-person passenger car and Mitsubishi Motors introducing its PHV concept car PX-MiEV to be used for long-distance driving while i-MiEV is to be used for shorter trips and daily commuting.

### *Battery and electric component suppliers*

Japan not only has several major car manufacturers but also several of the world’s foremost EV battery manufacturers. Car battery manufacturers collaborate closely in the development of EVs. The Japanese supply chains are often complex and contain a number of tiers. Vehicle battery suppliers to EV/HEV/PHEV are providing batteries. In the table be-

<sup>87</sup> Nikkei (2013) *Nihon Keizai Shimbun* January 29, 2013

low the cross-ownership of the main vehicle battery suppliers, by car and battery makers is shown. Panasonic and GS Yuasa supply batteries to other automobile makers as well.

Table 4-2 Co-ownership by vehicle battery suppliers by car and battery makers

Car maker	Vehicle battery supplier	Battery maker	Others
Mitsubishi Motor (4.4%)	Lithium Energy Japan	GS Yuasa (51%)	Mitsubishi Corp (44.6%)
Honda (49%)	Blue Energy	GS Yuasa (51%)	
Nissan (51%)	Automotive Energy Supply	NEC (49%)	
Toyota (80.5%)	Prime Earth EV Energy	Panasonic (19.5%)	

Source: *Toyo Keizai (2012)*<sup>88</sup>

The new relevant group of suppliers for EV comes mainly from the dominion of electric parts suppliers, from where battery makers source their components. These battery parts and materials (electrodes, electrolytes, inverters, and separators) manufacturers have invested and expanded their manufacturing capacity according overly optimistic projections of production plans for batteries for electrified vehicles by government ministries and market analysts.

However, due to the slow sales of EVs, these electric parts suppliers, who are a mix of large companies and SMEs, have now found themselves in a tough economic situation.

#### *Charging infrastructure providers*

Due to the limited driving range of EV, charging stations in public spaces are a must for further diffusion of EV.

The first group of charger infrastructure providers can be found owned and operated by the two vehicle manufacturers that have chosen to manufacture EVs – Nissan and Mitsubishi. They use their network of dealerships, but also associated or owned car rental agencies.

Helped by previous and upcoming substantial government subsidies, other traditional vehicle infrastructure providers have also started operating chargers. These include filling stations, highway service area operators, car parking centres, including airport parking. Also, non-traditional car infrastructure providers are cooperating with new unconventional partners. For example, a joint venture by CHUBU electric power and seven convenience store chains was launched to set up quick-charging stations in their parking lots, connected to quick charger network infrastructure, in the central areas of Japan. Examples can also be found in convenience store chains, suburban shopping centres, leisure centres like hot spa and cinema complexes, and individual shop owners. The public sector, such as city halls and hospitals, can be found to have some limited deployment.

#### *Service providers*

Also services focus on the need to charge the EV vehicles frequently, but also on how payments and business models around this new infrastructure can be put in place. For example, membership clubs have been started to provide EV users with detailed maps of location of chargers at flat rate; members can charge as many times as they like at both quick and normal charging stations in public spaces and ones listed for members at a monthly charge of SEK 68 (JPY 1,000).

<sup>88</sup> *Toyo Keizai (2012) Gyoukai chizu, Toyo keizai shinpo September 2012*

The whole IT solution platform for handling charging services and payments are receiving increased attention. For example, a cloud computing service (billing and settlement) named “Smart Oasis”, a network of quick-charging stations, has been launched by Unisys Japan (solution provider).

IT solution providers like Fujitsu, Hitachi and Unisys, have launched cloud computing services for billing and payment of EV charging, and information provision both to charging station owners and EV users. Fujitsu has provided location-based services with cloud computing to both charging station owners and EV users. Charging station owners receive usage of chargers, and EV users receive nearby charger station locations and charging cost information.

### *Consumers/users*

The miniscule sales of EVs in Japan despite the strong government’s growing supporting policies and the outspoken EV strategies from two major vehicle manufacturers leading to mass production makes data on actual buying and usage behaviour limited. However, it is clear that the much more affordable options for environmentally friendly vehicles such as HEV and smaller conventional cars are preferred. These vehicles are also showing competitive performance also in other areas than price and operational expenses compared to conventional cars.

## **4.2 Functional pattern of an electrified vehicle fleet in Japan**

This section describes the governance structure for electrification of the vehicle fleet in Japan, based on the innovation system functions identified in the TIS framework.<sup>89</sup>

### **4.2.1 Knowledge development and diffusion**

#### *The Electrical vehicle concept*

The automobile industry is one of the largest and most important industries in Japan. In 2009, automotive production accounted for 15.3% of the total value of Japan’s manufacturing.<sup>90</sup> The industry makes relatively large investments in equipment and R&D activities of 15.6% and 18.5%, respectively, making the industry a core industry not only economically, but also as a driving-force for innovation.

The discussion about what the traditional vehicle manufacturers’ competitive advantage and knowledge base is remains relevant to the development of EV. A car is in many ways one of the most complex, mass-manufactured, systems in modern society. Brand owners like Toyota and Ford are at the helm of a vast network of suppliers. They have fine-tuned the role of the system-integrator and, especially in Japan, built close ties and dependencies with their supplier network. The core of the system is the traditional fossil-fuelled combustion engine.

As increased electrification and digitalization of modern vehicles continues into the engine department this could imply a more modularized way of thinking. An electric engine is a comparatively simple device, with the battery package standing for the complexity. By comparison, an EV contains around two thirds or half the number of parts compared to an

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<sup>89</sup> For more info on the TIS framework, see Bergek et al (2008) *Analyzing the functional dynamics of technological innovation systems: A scheme of analysis*, 2008, *Research Policy*, (37), 3, 407-429.

<sup>90</sup> JAMA (2012) *Japan Automobile Manufacturers Association - Statistics*  
<http://www.jama-english.jp/statistics/index.html>

internal combustion engine vehicle. But more importantly, new industrial actors stand for the knowledge of these parts and systems.

This is a new reality for the traditional car manufacturer needing to develop skills in-house or via a new set of suppliers. There are clearly both benefits and drawbacks for an incumbent car manufacturer in exchanging their existing production and basic product architectures when investing in next generation vehicles. On a positive note, great opportunities exist for early successful entrants into the EV market, the Toyota Prius in the hybrid market being a case in point.

### *Battery technology and energy storage*

Energy storage in batteries is one of the most important issues now and in the future from different perspectives.

With the battery technology used today, mainly lithium ion batteries, it is unlikely that the operational range of an EV will be up to par with conventional cars in the near future. A breakthrough in battery technology would be needed for the range of an EV to increase substantially. Within the Japanese TIS, there are great hopes that such a breakthrough would stem from research and development efforts during 2013-2014. NEC and Panasonic have announced battery technologies that will increase power output by 30%. NEC's technology is based on manganese lithium-ion, which will reduce battery costs significantly while increasing output by 30%, while Panasonic's technology developed at Kyoto University, involves metallic lithium for the negative electrode and a newly developed high-performance polymer for the positive electrode also offering a 30% boost in power for a much lighter product.

The Japanese government puts a higher priority on research and development of batteries and related technologies than perhaps any other projects. Among national R&D projects, the "RISING" battery project is the largest and seen as key to continuing to hold a leading position in the battery field. The RISING battery project is led by Prof. Ogumi at Kyoto University<sup>91</sup> but includes participants from eight universities, 12 corporations, and four research institutes. It will run from 2009 until 2015 with approximately JPY 3,000 million (approx. SEK 240 million) in yearly funding, primarily from NEDO<sup>92</sup>.

Patent statistics indicate that Japanese battery manufacturers are currently the world leaders in research, including production capability, the increasing number of enterprises entering the EV and the lithium-ion market globally. However, although Japan is one of the world-leading countries in battery technology measured by number of patents, other countries, especially China, are significantly increasing the number of patents registered and academic papers presented. In the commercial domain, South Korean companies (Samsung and LG) have already passed Japanese companies as the world's largest battery suppliers. Japan has seen its leading position overtaken by other countries in electronics as the market matured over the past ten years and manufacturers are concerned that the same may happen as regards batteries in Japan.

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<sup>91</sup> NEDO (2012a) *Project outline of NEDO PISING Battery Project, Research & Development Initiative for Scientific Innovation of New Generation Batteries* [http://www.nedo.go.jp/activities/AT5\\_00104.html](http://www.nedo.go.jp/activities/AT5_00104.html) (Japanese), Kyoto University (2012) *RISING battery project home page* <http://www.rising.saci.kyoto-u.ac.jp/> (Japanese), Kyoto University (2012) *Brochure of NEDO PISING Battery Project, Research & Development Initiative for Scientific Innovation of New Generation Batteries* [http://www.rising.saci.kyoto-u.ac.jp/pdf/RISING\\_Battery\\_Project\\_en.pdf](http://www.rising.saci.kyoto-u.ac.jp/pdf/RISING_Battery_Project_en.pdf) (English)

<sup>92</sup> NEDO: *New Energy and Industrial Technology Development Organization, public research fund*

#### 4.2.2 Influence on the direction of search

Influence on the direction of search for fuel-efficient vehicles in general and EVs in particular can be found in sourcing from government, parts of industry and among consumers. In short the government has worked to make the EV innovation system attractive to enter, whereas the major industrial actors and consumers have so far shown they are open to a broader spectrum of different solutions to meet the need for convenient, eco-efficient and economically viable products.

##### *Government strategies and fiscal support*

Interestingly enough there have been major drives to introduce EVs previously on the Japanese market. Firstly in the 1970s as a means of curbing pollution as well as mitigating the negative impact of increased fuel prices after the oil crisis. Secondly, California's new laws on zero emissions in the 1990s, which spurred a major drive towards developing and gaining market acceptance for EVs. In both these cases the market formation could not take place due to high cost and poor battery performance. Through technological advancements some of these barriers have since been lowered.

There are several driving forces for the government to promote a paradigm shift in Japan's vehicle fleet.

Firstly, to reduce CO<sub>2</sub> emissions and fossil fuel use (improvement of fuel efficiency).<sup>93</sup> In 2008, 18% of CO<sub>2</sub> emission in Japan came from vehicles, 10 % of total emissions from private vehicles. Secondly, electrification of the vehicle fleet, is considered to have the potential to be a new economic growth engine. Japan leads in several of the technologies relevant for the electrification of the vehicle fleet, e.g. battery and light materials technologies. Finally, changing from combustion engines to electricity can be part of the overall strategy to secure Japan's energy supply. Japan is wholly dependent on imports of energy resources such as crude oil, natural gas and coal. Electric power can be produced from natural resources, including renewable energy. Also, bio-based fuel and newly found natural resources could be used for hybrid vehicles. EVs are important components of the smart grid concept. By connecting vehicles with houses (V2H) and/or grid (V2G), the batteries buffer fluctuating input of renewable energy, such as solar and wind, and evens out the peak loads in power consumption. The stored energy in EV/HEV/PHEVs can also be electric power supplies in natural disaster situations.

As described above, the government has put forward strategies for growth in general and for next-generation vehicles in particular, and points out long term directions and qualitative and quantitative goals. Furthermore, a public procurement strategy by national and local government, in addition to demand for commercial use, has been strengthening the attractiveness to enter the arena for various players. The goals and strategies of the policy makers (primarily the Ministry of the Environment (MoE) and the Ministry of Economy,

<sup>93</sup> NPU (2012) *Nihon saisei senryaku (Comprehensive strategy for the rebirth of Japan) National Policy Unit 2012* <http://www.npu.go.jp/saisei/images/pdf/RightNaviHonbun.pdf> (Japanese), METI (2010) *Next Generation Vehicle Strategy 2010 Ministry of Economy, Trade and Industry April 2010* <http://www.meti.go.jp/press/20100412002/20100412002-3.pdf> (Japanese) <http://www.meti.go.jp/english/press/data/pdf/N-G-V2.pdf> (Outline in English) [http://www.meti.go.jp/english/press/data/20100412\\_02.html](http://www.meti.go.jp/english/press/data/20100412_02.html) (English announcement), JAMA (2010) *News from JAMA Next-generation vehicles strategy in Japan, Japan Automobile Manufacturers Association Issue No. 4, 2010* [http://www.jama-english.jp/europe/news/2010/no\\_4/art2.html](http://www.jama-english.jp/europe/news/2010/no_4/art2.html) (English), Ishikawa (2011) *Denki jidousha ga ichiban wakaruru (Easy to learn about electric vehicle) Gijutsu Hyoronsha September 2010* (Japanese)

Trade and Industry (METI)), however lofty and overly optimistic compared to those of private analysts, have set the agenda for both policy and industry in Japan.

Local municipalities have tried to promote an ultra-compact type of EV as a way of handling the depopulation and aging of Japan's rural areas. Ultra-compact EVs charged by normal AC outlets at homes, is seen to provide wider opportunities for intra city/town use and would help elderly people living alone and isolated from the public transport network. As a background, the number of petrol stations has been decreasing, especially old petrol stations in rural areas. This is due to the partial revision of the Fire Service Act, i.e. petrol tanks older than 40 years must be renovated.<sup>94</sup>

### *Industry strategies and consumer demand*

Societal and consumer demands such as fuel efficiency and low emissions are driving the automotive industry to develop new generation cars. The market is clearly open to alternative routes than pure EV. However, essential parts of the EV concept are shared by HEV, PHEV and FCV; such as electric engines and powertrains, batteries and lightweight constructions, and all concepts will gain from progress in these areas.

Toyota's search for new and long-term business opportunities resulted in the development of the HEV Prius in the 1990s. They identified the features for "the car of the 21st century" as fuel and resource efficiency, i.e. low weight and low emissions. The HEV was a pragmatic way to meet customer needs and yet overcome the main obstacles for EVs; high cost and weight for batteries with sufficient range and lack of charging infrastructure.

The Prius and Aqua HEVs were the best- and second best-selling car in the second half of 2012. Toyota announced it would be releasing another 21 new HEV models by the end of 2015. Total sales of HEV in 2012 were expected to exceed 1 million vehicles and Toyota expects HEV sales to exceed 1 million vehicles a year through 2015.

Consumer response to HEV influences the direction of other car manufacturers. Nissan COO Mr Toshiyuki Shiga announced in December 2012 that the company would release 15 new HEV models, one of which would be a PHEV. The most visible industrial proponent Nissan has in other words changed its short-term strategy from only EV to HEV. Also, the other EV manufacturer Mitsubishi released its Sports Utility Vehicle PHEV "Outlander" in January 2013.

### 4.2.3 Entrepreneurial experimentation

As often in Japan, starved on venture capital and the dominance of innovation in large firms, experimentation largely takes place inside the companies and in academic-industry collaboration.

It stands clear that the Japanese firms are not betting on one single solution for the next generation vehicles. The prevalent mix of technology choices for all Japanese car manufacturers are EVs, PHEVs, HEVs, and FCVs, but it should also be noted that the major Japanese car manufacturers have diverse strategies for the priorities and timing of these technologies. One case in point is the substantial investment in fuel cell technologies in parallel to EVs. The first commercial FCVs are scheduled for release in Japan in 2015. Three Japanese car manufacturers, Toyota, Honda and Nissan, and ten energy companies jointly announced in a statement on January 13 2011 that 2015 is the target year for an

<sup>94</sup> Sankei (2012) Gas station number decreasing Sankei web news June 2012  
<http://www.sankeibiz.jp/business/news/120622/bsd1206221430020-n1.htm>



early commercialization of fuel cell vehicles in Japan. Hydrogen fuel suppliers have also set goals for construction of hydrogen fuelling stations by 2015<sup>95</sup>.

Continuing on new thinking initiated by the large incumbent firms, there is a drive to develop an ultra-compact EV for personal mobility by conventional car makers, such as, Toyota, Honda<sup>96</sup>, and Nissan, and also by some new entrants. Since an EV has a much simpler structure than conventional cars, SMEs can try out this new business category with less financial resources.

Local municipalities have launched projects to promote such ultra-compact EVs, especially for elderly people, because most local governments have areas isolated from the public transport network and have the problem of an aging population and independent living. The central government has followed the move. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) released Guideline for introducing ultra-compact EV in June 2012.<sup>97</sup> Then the ministry announced in February 2013 that a new ultra-compact vehicle category had been set, and opened the procedure for type approval to run on public roads. At the same time, the MLIT announced a call for applications for subsidies (half the cost) for introductory or experimental pilot projects for certain areas, not for purchasing small numbers of vehicles, totalling SEK 26 million (JPY 381 million) under FY2012 supplementary budget and SEK 14 million (JPY 201 million), FY2013 initial budget. The ultra-compact vehicle is not necessarily to be EV, but is a category with lower energy consumption, about one sixth of that of petrol engine cars and half a normal size EV, between the two-wheeler category with up to 50 cc engine capacity and mini-cars with up to 660 cc engines. It has one or two seats, and the vehicle is not allowed to run on the highways. The MLIT expects this new vehicle to contribute to energy saving and a low carbon society, the creation of new means of transportation for everyday life, a new market and demand, and contribute to support mobility for families with children and elderly people, and promote tourism and areal support.<sup>98</sup>

The infrastructure around a successful deployment of EV is not only physical and perhaps here smaller players can and will make contributions. One example is roadside services. Nissan, together with the JAF (the Japan Automobile Federation) is furthermore testing a moveable roadside quick charger. The truck can recharge EVs that have been stranded and it can also tow away vehicles. Nissan believes that the addition of a roadside charger for emergencies will make customers more comfortable driving EVs. The AAA (American Automobile Association) announced in June 2011 that they will offer roadside charging of EVs to its members. The AAA will have trucks with several different charging modes, both DC fast charging and AC slow charging.

<sup>95</sup> Hara, Kohjiro (2011) *Research and Development of Fuel Cells Vehicle and Hydrogen in Japan* [http://www.hfc2011.com/wp-content/uploads/2011/07/HFC2011\\_Japan.pdf](http://www.hfc2011.com/wp-content/uploads/2011/07/HFC2011_Japan.pdf)

<sup>96</sup> Honda (2012) Press release, Honda Motor <http://world.honda.com/news/2012/4121113Micro-EV-Commuter-Prototype/index.html>

<sup>97</sup> MLIT (2012) *Guideline for introducing ultra-compact EV Ministry of Land, Infrastructure, and Transport June 2012* <http://www.mlit.go.jp/common/000212867.pdf>

<sup>98</sup> MLIT (2013a) *Ultra-compact vehicle promotion* <http://www.mlit.go.jp/common/000986236.pdf>

MLIT (2013b) *Announcement of Ultra-compact vehicle category creation* [http://www.mlit.go.jp/jidosha/jidosha\\_fr1\\_000043.html](http://www.mlit.go.jp/jidosha/jidosha_fr1_000043.html)

MLIT (2013c) *Presentation of promotion of ultra-compact vehicle* <http://www.mlit.go.jp/common/000986511.pdf>

#### 4.2.4 Market formation

##### *Vehicle supply*

There were approximately 12,000 EVs in use in Japan in 2011. Of these, most are normal passenger cars and the remainder trucks, buses or other special vehicles. The large increase in EVs during fiscal year 2009 and fiscal year 2010, as can be seen from Table 4-3, can be explained by the launch of Mitsubishi's i-MiEV in July and the Nissan Leaf in December 2010. In Japan, most electric vehicles are either the Mitsubishi i-MiEV or the Nissan Leaf. Before the market introduction of those two, electric vehicles in Japan were conventional vehicles that had been converted to run on electricity. By mid-November 2011 more than 5,000 i-MiEVs and 8,500 Leafs had been sold in Japan, combined more than 12,500 EVs (Berman 2011, Mitsubishi Motors 2011).

i-MiEV and Leaf use a lithium ion battery and an advanced battery management system and invertors. Converted EVs use conventional lead-acid storage battery, which most of the cars carry for starting the engine. It was a kind of global trend toward eco-friendly vehicles and they were used in limited areas such as national parks.

Table 4-3 Eco-friendly passenger vehicle sales in the domestic market

Type	FY 2007	FY2008	FY 2009	FY 2010	FY2011
HEV	88438	109739	452098	447626	633417
EV	60	46	1622	7110	12202
PHEV	0	0	165	214	3753

*\*Note: EV: except 2 wheel vehicle*

*Source: Next Generation Vehicle Promotion Center*

HEV has already reached the mass market for passenger vehicles, since Toyota's HEV (Prius and AQUA, called "Prius C" in the USA) were the best- and second best-selling car in the domestic market in the second half of last year (2012). Although numbers are limited, other HEV models from Toyota and Honda can also be seen on the roads.

However, for other types, such as EVs, PHEVs and CDVs, penetration is lagging far behind HEVs, so they are still in "nursing markets".

The ultra-compact EV has just entered "nursing markets", which are supported with public money and mainly within pilot projects.

##### *Governmental support to market formation*

The extent of fiscal support in various forms to form and support a growing market for new generation vehicles, including EVs, has been extensive throughout the years.

To stimulate domestic demand, the Japanese government introduced temporary tax reduction/exemption for fuel-efficient vehicles with good environmental performance for three years, acquired between 1 April 2009 and 31 March 2012. The proportion of these taxes is approximately 40% of the entire amount of tax and the reduction of these taxes is playing an important role in stimulating the next generation vehicle market.

Several subsidy programmes have also been tried, often tied to the numerous economic stimulus packages that have been launched in recent years to revitalize the Japanese economy in general. For example, since 1998 and continuing through fiscal year 2011, there is the "Subsidy for promotion of clean-energy vehicle (tentative translation)" for purchases of

EVs, PHEVs, clean diesel cars and charging equipment. The subsidy is available to local government/public organizations, private companies and individuals. The limit of subsidy for vehicles is half of the difference between the cost of an EV and a similar type of conventional vehicle with an upper limit of SEK 70,000 (JPY 1 million) and SEK 27,000 (JPY 400,000) for EVs, PHEVs and clean diesel cars, respectively and half of the cost for chargers.

The programme was followed by allocated government funds of SEK 18.7 billion (JPY 275 billion) or SEK 6,800 (JPY 100,000 JPY) per passenger car open for use between April 2012 and March 2013. The current METI has recently proposed subsidies for private purchases of next generation vehicles totalling SEK 2 billion (JPY 30 billion) under FY2013 initial budget. The Ministry of Land, Infrastructure, Transport and Tourism proposes launching some demonstrations of local transport with EVs, such as taxis and buses, SEK 122 million (JPY 1,800 million) and pilot projects for introducing ultra-compact vehicles in intra-city/town use, SEK 26 million (JPY 381 million) under FY2012 supplementary budget and SEK 41 million (JPY 600 million) under FY2013 initial budget.

Perhaps the largest new commitment under the new government hit the news in February 2013 when METI proposed a project to expand charging station network nationwide under a supplementary budget of SEK 6.8 billion (JPY 100.5 billion), to increase the number of chargers to 100,000. This would help ease early adopters' worry about running out of power during an intercity drive.

#### *Vehicle demand and consumer behaviour*

It is important to understand the driving patterns in Japan to fully appreciate market formation, and especially when examining the economic incentives consumers see from investing in a relatively pricey next generation vehicle.

The economic advantage of buying an EV over a conventional car differs throughout the world due to differences in driving range, cost of petrol and electricity and incentives provided. The Boston Consulting Group compared the pay-back time for buying an EV instead of a conventional car in 2020 in Europe, North America, China and Japan taking into account expected technological developments that would decrease the price and operating costs of an EV and assuming an EV owner drives the same distance as an owner of a conventional ICE-car (BCG 2010).

The study showed the time to break even was by far longest in Japan. This is because in Japan people drive less on average and petrol prices are not high enough to compensate. The study expected that pay-back time for an EV bought in Japan in 2020 would be 25 years without any incentives. The more one drives the more money saved since recharging an EV is considerable cheaper than filling up a normal car with petrol. In the United States, petrol prices are low but driving distances are much longer than in any other parts of the world. The high price of petrol in combination with relatively long driving distances makes the time to break-even shortest in Europe. (BCG 2010)

Consumers have proved sensitive to the price and operating costs of vehicles. The budget for tax breaks and government subsidies for purchasing eco-friendly vehicles ran out before its time limit. For example, the allocated government funds for April 2012 to March 2013 had already run out in September 2012. Consumers need price-competitive EV against other types of vehicles, a longer driving range and more charging stations. Setting up 200V AC outlets close enough to home or apartment parking places could be a bottleneck for some consumers, especially those living in large cities in Japan. Due to the high price of land, many people rent a parking space near their home. The METI also gives

subsidies to apartment owners and car park business owners for such cases, both on charger and construction costs.

### *Formation of charging infrastructure*

As for charging infrastructure, there are government initiatives in place also here.

Quick charging is seen as a key factor for wider use of EVs. Japan has taken a lead with CHAdeMO, a system for quick charging developed by the Tokyo Electric Power Company in collaboration with the major Japanese car manufacturers. In Japan, there are 2,140 quick-charging stations in use as of January 2013. Compare this to 601 in Europe and 154 in the United States with a fast increase in deployment speed in all markets.<sup>99</sup> The two major EVs in the market, the Mitsubishi i-MiEV and the Nissan Leaf, support quick charging through the CHAdeMO protocol. Even with quick charging, 30 minutes is a long time compared to the time it takes to refuel a conventional car. The range of an EV is difficult to estimate since it differs depending on how the car is driven and used. City traffic and use of air-conditioning will lower the driving range considerably. The driving range under optimal conditions can be double that of more demanding driving conditions.

CHAdeMO is the proposed Japanese standard for quick charging and the domestic actors are gravitating around the CHAdeMO association, founded by Japan's largest electric utility, TEPCO (Tokyo Electric Power Company) and four Japanese car manufacturers, Nissan, Mitsubishi Motors, Fuji Heavy Industries and Toyota. About half the member companies are Japanese and the other half companies from other countries. To develop and sell a CHAdeMO charger one needs to be a regular member of the CHAdeMO association. There are CHAdeMO chargers from 30 different companies, including ABB, on the market.

The government has a target of 5,000 CHAdeMO quick chargers installed by 2020. Basically, all CHAdeMO chargers were until recently free to the general public in Japan, but quick charger owners began paying their quick charges with a smart card in 2012. Charging stations are installed as a service, for example at a parking lot free to use for all parked cars. Japan has toll highways and some of the highway companies have also installed chargers at their service stations along the highway. Shopping centres and convenience stores install chargers to attract customers.

On Okinawa, the most southern tropical island group of Japan and which attracts many tourists, there is an ongoing project with EV rental cars that includes a payment per charge. A new company established by local businesses, rental car companies and travel agencies called the Advanced Energy Company (AEC) has installed 27 quick chargers in 18 locations. 220 EV cars are rented out to the large numbers of tourists that visit the island every year.

The "EV/PHEV Town" initiative is a model project to implement the demonstration of full-fledged diffusion of EVs and PHEVs, which is stipulated in the METI's "Action Agenda for a Low Carbon Society".

#### 4.2.5 Legitimation and resource mobilization

Although the EV (PHEV) market is still at the nursing stage, EV has been socially accepted as one part of the next generation of vehicles that will run on our roads. Standardization, whether the Japanese standard gains international traction or not, and deployment

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<sup>99</sup> CHADEMO (2013) CHADEMO Association Press release January 22, 2013  
<http://www.chademo.com/wp/wp-content/uploads/2013/01/CHAdeMO-Pressrelease.pdf>

plans for the necessary quick charger is helping to stabilize the picture of EV as a serious option for the future. It can also be argued that the Great East Japan Earthquake made people more aware of energy usage and started a green trend in the society which improved the image of EVs in Japan.

That the vehicle industry is keeping several options open and not investing whole-heartedly in EV (but HEV in the short term and FC in the long term) naturally erodes the legitimization process.

However, the continuing strong support from the government especially for the choice of EV as a forerunner technology towards a more environmentally adapted transportation sector is sending strong signals to consumers and industry that potential necessary legislation (e.g. for safety) will also be prioritized by the government.

One major way Japanese industry has made it easier to enter the ecosystem around EV is through standardization, more specifically of the crucial infrastructure for charging/refuelling the vehicles. Japan's goal is that CHAdeMO will be the de-facto world standard for quick charging EVs but the standard has had several international setbacks, where the COMBO standard supported by Audi, BMW, Daimler, Ford, Volkswagen and General Motors for example, has achieved greater momentum. It certainly does not help the resource mobilization of a strong Japanese standard when Toyota for example seems ambivalent to giving CHAdeMO its full support – and also releasing models that do not support the standard. Having said this, the speed at which Japan is rolling out the (quick) charging infrastructure is world-leading, and early experiences from this will help refine the EV market offering. As an important step in resource mobilization, the CHAdeMO quick charger specification was opened to the public in September 2012.<sup>100</sup> Differences in standardization can also become problematic in Japan's trade negotiations if it is labelled a non-tariff barrier to foreign-made EVs.<sup>101 102</sup>

### 4.3 Conclusion

Electrification of the vehicle fleet in Japan is advancing if the hybrid electric vehicles that made up 27% of new passenger cars in 2011 are included. Hybrid electric vehicles continue to be pushed by Japanese vehicle manufacturers and with competitive pricing are increasingly well-received by consumers thanks to public subsidies and tax breaks and relatively good performance.

Electric vehicles and plug-in hybrid electric vehicles are in many ways a completely different animal with a disappointing market share of 0.7% despite efforts from the two vehicle manufacturers Nissan and Mitsubishi. The lack of charging infrastructure and overall low vehicle performance combined with relatively high price has only attracted early adopters and limited government public procurement. The greatest hopes are perhaps for a new class of innovative ultra-compact electric vehicles subsidized by the government for intra-city use in limited rural areas. The existing mass-produced hybrid options and the diversified strategies of the car manufacturers can be interpreted as major blocking mechanisms for further rollout of electric vehicles.

<sup>100</sup> CHADEMO (2012) CHADEMO Association member list <http://www.chademo.com/wp/wp-content/uploads/2012/11/memberlist.pdf>, JISC (2012) Japanese Industrial Standards Committee <http://www.jisc.go.jp/app/pager?id=61580>

<sup>101</sup> [http://www.japantimes.co.jp/news/2012/06/26/business/ev-charger-rivals-challenge-japan/#.USs\\_Hh3DCQt](http://www.japantimes.co.jp/news/2012/06/26/business/ev-charger-rivals-challenge-japan/#.USs_Hh3DCQt)

<sup>102</sup> <http://www.greendump.net/tag/sae-combo-charger>

The fundamental inhibitors are low battery performance and lack of charging infrastructure. Substantial efforts are being made in government and private sector R&D to improve current battery performance and battery management technologies and to develop a new battery that could be mean a breakthrough for electrification of the vehicle fleet and some progress has been made over the last two years. However, the car manufacturers themselves are keeping several strategy options quite open, where a major bet is on hydrogen fuel cells for commercialization in 2015 as a parallel contributor to a future vehicle fleet.

The Japanese government has in policy mainly stayed with the sound principle of technology neutrality and crafted incentives for all eco-efficient next generation vehicles. The primary policy tools for this promotion are through fiscal incentives, directed towards car users with tax breaks and subsidies, infrastructure with subsidies, and direction of publicly funded research.

An exception from the technology neutrality principle would be the focused efforts with the use of fiscal policy to push a substantial build-out of charging infrastructure for electric vehicles and plug-in hybrid vehicles. The rationales for this particular focus on electric vehicles and plug-in hybrid vehicles are multiple and include CO2 reduction, a need to diversify electricity resources, and also use electric vehicle batteries in a larger renewable energy infrastructure connected to residential houses where the batteries could help buffer energy and manage peak electricity consumption. For this to succeed, the volumes of EVs would need to increase dramatically, which might help explain the government's current unrealistically high projections, especially of electric vehicles. Even then, the primary question concerns the outlook for changing Japan's primarily fossil fuel primary energy mix. A more plausible explanation for the Japanese government's continuing funding is that it is part of current economic stimulus plans to help out the battery and electronic parts sector for example, which has been identified by the government as a future driver of growth.



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