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13TH ELECTRIC VEHICLE SYMPOSIUM (EVS-13)

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Een impressie van de ontwikkelingen op het gebied van elektrisch vervoer

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Verantwoording

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Abstract

From 13 to 16 October 1996 the 13th Electric Vehicle Symposium (EVS-13) was held in the city of Osaka in Japan. The symposium was well attended with 1600 participants from 33 countries. There was a total of 185 technical presentations covering 16 different topics e.g., battery research, standardisation and air quality. The symposium made it very clear that compared to the situation two years ago, we are in a totally different phase of development of electric vehicles (EVs). The situation we are in today is one of realisation of projects and the actual series production of purpose designed EVs. Because of this new phase the need for standardisation has become more obvious. One simple example is the need for a common standard for the plug to connect the charger to the vehicle. The quality and the performance of the vehicles presented was impressive. The automotive industry is definitely taking the development of EVs and hybrid vehicles very serious. One key issue for EVs is the battery technology. Although there is no revolution in the performance of battery systems to be expected, the amount of effort put into the design and research of batteries and the progress achieved is very impressive non the less. The development of Nickel Metal Hydride (NiMH) and Lithium Ion batteries both hold great promise for respectively the mid term and long term use in Evs. The presentation of technologies competing with batteries were not great in number for the moment, but e.g., the development of fuel cells received a lot of interest as one very promising new technology. According to Mr. Shoichiro Toyoda, chairman of the Toyota Motor Corporation and guest speaker at the symposium, three ingredients are necessary to make the EV successful: technological breakthrough in the battery performance, government support and consumer awareness. The Electric Vehicle Symposium now takes place on an annual basis. EVS-14 will take place on 15-17 december 1997.

INHOUD

1. INLEIDING

Het rijden met de General Motors EV1 is een geweldige ervaring. Dit is het voertuig dat de toekomst van het elektrisch vervoer in grote mate zal bepalen. Natuurlijk is het niet zo dat iedereen op een 2-zits sportwagen met een 102 kW (137 pk) motor en een acceleratie van 0-100 km/uur onder de 9 seconden zit te wachten, eerder het tegendeel, maar het is wel het soort voertuig dat heel goed het boegbeeld van de Electric Vehicle (EV) industrie kan zijn. Het voertuig waardoor de mensen hun visie op elektrisch vervoer drastisch zullen moeten aanpassen. Daarom denk ik dat het welslagen van de GM EV1 belangrijker voor de EV industrie is dan men op het eerste gezicht zou denken. Eerlijkheidshalve moet ik er aan toevoegen dat ook andere EV's zoals de Toyota RAV4L EV en de Honda EV zeer overtuigende voertuigen zijn die qua concept bij een groter publiek zullen aanslaan.

Het symposium werd bezocht door ongeveer 1600 deelnemers uit 33 landen, waarvan het merendeel uit Amerika en Japan, met Europa als goede derde. Er waren 47 technische (presentatie) sessies over een 16-tal aandachtgebieden met in totaal 185 presentaties (van ongeveer 20 minuten). Een groot deel van de presentaties (36) ging over batterijen. Het was niet mogelijk om alle presentaties te volgen aangezien ze in een zestal sessies werden gegeven met per sessie ongeveer acht parallelle presentaties. Van de 16 aandacht gebieden gingen er 5 over niet technische onderwerpen; zoals standaardisatie, marktresearch, EV beleid en luchtkwaliteit, betrokken op het aantal presentatie sessies waren het er slechts 8 van de 47. EVS-13 was dus een nogal op de techniek geconcentreerd symposium. Verder waren er nog 70 postersessies.

Er waren ook nog forumsessies voor het voltallige symposiumpubliek over de volgende onderwerpen; overzicht van de regionale EV situatie, over nieuwe concepten en over realisatie.

De teneur van deze discussies is dat we nu toch in een duidelijk andere fase zitten dan voorheen, zelfs vergeleken met twee jaar terug, en wel in de fase van realisatie van projecten en daadwerkelijke productie van voertuigen. Verder is heel duidelijk de noodzaak van standaardisatie naar voren gekomen, met als klein voorbeeld de vele verschillende stekkers voor zowel het conductief als inductief laden van EV's.

Het verhaal over EVS-13 is zoveel mogelijk gebaseerd op persoonlijke ervaringen, opgedaan tijdens de vele sessies. Aangezien het onmogelijk was om bij alle (parallelle) sessies aanwezig te zijn heb ik ook informatie gehaald uit de 'Symposium Proceedings' (770 blz) voor die ontwikkelingen die ikzelf van belang achtte en die waarvoor extra aandacht was gevraagd. Ik heb voor dit laatste alle verhalen gelezen en verwerkt over o.a. regelgeving, infrastruktuur, kostprijsontwikkeling, marktintroductiestrategieën en hybriden.

2. ALGEMENE ONTWIKKELINGEN

De GM EV1 staat in mijn ogen centraal in alle ontwikkelingen op het gebied van EV's en veel wat er over de EV industrie te zeggen valt kan aan dit voertuig worden opgehangen t.a.v. dedicated (groundup) ontwikkeling, luchtweerstand, gewicht (materialen body en chassis), met als enige uitzondering de batterij (Valve Regulated Lead Acid, VRLA) die niet zozeer een technologisch hoogtepunt is als een beschikbaar en betaalbaar alternatief. Met deze batterij heeft de GM EV1 een aktieradius van 150 km onder Highway condities. Overigens is binnen twee jaar een versie met een NiMH (Nikkel Metaal Hydride) batterij van Ovonics (USA) te verwachten.

Op de GM EV1 en de Honda EV na zijn alle ontwikkelingen van de grote automobiel fabrikanten gebaseerd op bestaande voertuigen, en dit heeft m.i. maar één nadeel, de ongunstige plaatsing van de zware en grote batterij, met als gevolg een mogelijk verslechterd dynamisch weggedrag. Plaatsing tussen de beide assen zou de beste optie zijn voor dit probleem, maar dit is meestal alleen bij voertuigen mogelijk die als EV zijn ontworpen. Uitzondering op deze regel is de Toyota RAV4L EV, een afgeleide van de ICE (Internal Combustion Engine) versie, waarbij de batterij onder de vloer en tussen de assen geplaatst kon worden. Een ander veel genoemd argument ten voordele van dedicated ontwikkelde EV's is dat ze lichter gemaakt kunnen worden door het gebruik van advanced composites. Dit is natuurlijk maar zeer ten dele waar, want ook conventionele voertuigen kunnen zo gemaakt worden en hebben er hetzelfde voordeel van. Hetzelfde geldt voor een lage luchtweerstand, al geeft de GM EV1 met een Cw van 0.19 aan dat zo'n waarde er voor een ICE voertuig voorlopig niet inzit gezien de verstorende werking van de benodigde luchtinlaat voor de grote koellucht behoefte van de motor.

Een ander voordeel van het gebruik van bestaande ICE voertuigen wordt gedemonstreerd door Renault die de Clio Electrique op de bestaande productielijn maakt waar alle brandstof versies ook gemaakt worden. Deze productielijn is zo flexibel dat alle versies door elkaar gemaakt kunnen worden. Dit geeft de fabrikant de mogelijkheid om de elektrische versie op bestelling te maken naarmate er vraag is en niet gedwongen is om (kleine) series te maken. De aanpassing van de bestaande productielijn vergt maar een relatief kleine meer investering in vergelijking met een volledig nieuwe dedicated EV productielijn. Deze aanpak heeft ook een lagere kostprijs van de EV tot gevolg.

3. BATTERIJEN

Verreweg de meeste aandacht op het gebied van batterij ontwikkeling is gericht op de NiMH en Li-Ion technologie. Waarbij de NiMH batterij meer als de mid-term oplossing wordt gezien en de Li-Ion als long term oplossing. Opvallend is dat Europese batterij fabrikanten zeker in commercieel opzicht achter lopen bij Amerika en Japan voor wat de NiMH technologie betreft en achter bij met name Japan op het gebied van Li-Ion technologie. In Europa is men teveel gefixeerd geweest op de NiCd batterij die, naar nu duidelijk is geworden, de mindere is t.o.v. de andere genoemde technologieën. Een mogelijke verklaring is het ontbreken van een voldoende grote industrie voor consumenten elektronica. Zowel de NiMH als de Li-Ion batterijen zijn commercieel ontwikkeld voor de consumenten elektronica markt. Waarbij de Li-Ion technologie met name is ontwikkeld voor video camera's, mobiele telefonie en notebook computers, waarbij de duurdere batterij technologie, zeker in het begin, door de hogere verkoopprijs van het product werd gerechtvaardigd. Er is zeer veel aandacht voor Li-Ion batterijen, die voor de duurdere consumenten elektronica al volop beschikbaar zijn tegen een acceptabele meerprijs. Voor EV's is er maar één fabrikant die in staat zal zijn om op korte termijn Li-Ion batterijen te leveren en dat is Sony, niet toevallig ook de grootste fabrikant van deze batterij voor consumenten elektronica. De grote vraag is m.i. of we hybride voertuigen nodig hebben als de NiMH en Li-Ion technologie zich ontwikkeld als verwacht en dan heb ik het nog niet eens over de verbeteringen in de aandrijving zoals asynchroon motoren, hogere efficiëntie bij remenergie recuperatie. Dit zou toch heel goed een trend kunnen zijn, beperkte range met loodzuur batterijen, en voor wie verder wil NiMH of Li-Ion batterijen tegen een meerprijs. De ontwikkelingen in de consumenten elektronica geven de richting aan waarheen het gaat met batterij technologieën. NiHM heeft NiCd al vervangen bij die toepassingen die of een hoge capaciteit vragen of een laag gewicht. Dit is niet zo vreemd gezien het grotere potentieel van NiMH. Volgens een aantal batterijfabrikanten zal de kostprijs van de NiMH batterij die van NiCd evenaren of op z'n minst zeer dicht benaderen.

Een aspect dat met batterijen samenhangt is de ontwikkeling van batterij monitoring systemen die nodig zijn om tot een optimale benutting van de batterij capaciteit te komen. Zo'n systeem is ook van belang om tijdens laden en ontladen de laadconditie exact weer te geven. Er waren een aantal presentaties die over deze systemen gingen.

3.1 Lood zwavelzuur

De toekomst voor loodzuur batterijen zal beperkt blijven tot toepassingen in EV's met een kleine actieradius, zoals stadsvoertuigen, maar het is de vraag wat de prijs van geavanceerde batterijen zal worden indien ze in grote hoeveelheden gemaakt gaan worden. Mogelijk dat geavanceerde batterijen ook voor stadsvoertuigen interessant gaan worden want er kan dan een kleiner gewicht aan batterijen meegenomen worden, met alle voordelen van dien. Een andere trend zou kunnen zijn dat van een EV twee versies op de markt komen, één met een loodzuur batterij en een beperkte actieradius, en één met een geavanceerde batterij en een grotere actieradius. Deze trend is al enigszins waarneembaar bij Peugeot met de 106, die zowel met loodzuur als NiCd batterijen te leveren is, deze laatste optie tegen meerprijs.

3.2 Lood zwavelzuur (bipolair)

Horizon (Electrosource): een semi bipolaire batterij, dit is een van de weinige positieve ontwikkelingen op het gebied van loodzuur batterijen. Het bedrijf kreeg in 1996 een US award voor de ontwikkeling van de Horizon batterij gekregen. Chrysler heeft deze batterij gekozen voor de nieuwe EPIC Minivan.

3.3 Natrium zwavel

ABB - Een van de conclusies van het Rügen project in Duitsland is dat Natrium zwavel batterijen in het dagelijks gebruik niet voldoen. Ford heeft zijn onderzoek naar deze batterij gestaakt en de fabrikant ABB gaat niet door met de ontwikkeling. De ontwikkelingen van de Na-S batterij bij Silent Power, een dochteronderneming van RWE (de grootste elektriciteits maatschappij in Duitsland), zijn ook gestopt.

3.4 Natrium nikkelchloride

AEG en Zebra PowerSystems - Zebra - Deze batterij is nog steeds in ontwikkeling en de fabrikant gelooft er stellig in, wat begrijpelijk is. Minder veelbelovend dan de andere geavanceerde batterijen vanwege de hoge operationele temperatuur. Hierdoor is de batterij niet erg flexibel in het gebruik, vooral bij het niet gebruiken van het voertuig. De hoge temperatuur vraagt ook speciale hulp systemen om de batterij op temperatuur te houden, de warmte kan echter ook benut worden voor interieurverwarming. De ontwikkelingen door met name AEG van de Zebra batterij zijn redelijk overtuigend.

3.5 Nikkel cadmium

Op zich een batterij met vele goede eigenschappen zoals; onderhoudsvrij, geschikt voor lage temperaturen, redelijke energie-inhoud, betaalbaar. De komst van de NiMH batterij hebben de goede vooruitzichten echter getemperd. De batterij zal het uiteindelijk afleggen tegen de NiMH technologie. Saft - is de leverancier van NiCd batterijen voor EV's en levert o.a. aan Peugeot, Renault en Citroën. In deze toepassingen is de actieradius van de voertuigen ongeveer 100 km. Het ontwikkelingspotentieel van de NiCd batterijen biedt niet veel ruimte voor verbetering van de capaciteit.

3.6 Nikkel metaalhydride

De batterij technologie voor de middellange termijn. Matsushita - Toyota gebruikt hem al in de in Japan commercieel beschikbare RAV4L EV, waarmee een actieradius mogelijk is van meer dan 200 km (volgens de 10.15 mode, urban driving). Ondanks dat de RAV4L EV in Japan bijna 3 keer zoveel kost als de basis versie met IC motor (4,950,000 Yen versus 1,800,000 Yen), is hij 'slechts' 75% duurder dan de luxe versie (2,800,000 Yen) waar je hem qua uitrusting eigenlijk mee zou moeten vergelijken. Deze laatste vergelijking zul je over het algemeen niet in artikelen over dit voertuig vinden. Volgens batterijexperts is dit een koopje voor een voertuig met deze batterij technologie! Saft - Dat Europa achter loopt blijkt wel uit het feit dat Saft (Frankrijk pas in 1999 klaar is voor de marktintroductie van een NiMH batterij voor EV's. De voordelen van NiMH worden wel door Saft onderkend. Daar waar een NiCd batterij van Saft nu een range geeft van 100 km (vier persoons EV) zal een NiMH batterij volgens hun verwachting een range van 160 km geven. De kosten per km zal volgens opgave van Saft, bij een gelijke range, ongeveer 5% hoger uitvallen voor NiMH dan voor NiCd. Anders gezegd zal voor een NiMH batterij met een 60% grotere capaciteit (en range) meer dan 60% extra betaald moeten worden t.o.v. een NiCd batterij. De extra capaciteit van een NiMH batterij heeft zijn prijs! Concurrenten als Ovonics (USA) en Matsushita (Japan) zijn al zo ver dat ze NiMH batterijen voor EV's in kleine series kunnen gaan maken. NiMH batterijen hadden in het begin van hun ontwikkeling nog als groot nadeel de hoge zelfontlading, maar dat probleem is tot acceptabele waarden teruggebracht (minder dan 15% per maand). Voor NiCd is de zelfontlading vergelijkbaar. Ovonics - De Solectria Sunrise heeft in de 1996 Tour de Sol, een race over de openbare weg in de VS, een afstand afgelegd van 600 km op één batterijlading. De batterij in kwestie was een prototype NiMH batterij van Ovonics. De GM EV1 zal naar verwachting binnen twee jaar met een Ovonics NiMH batterij verkrijgbaar zijn. Varta - heeft recent weer een contract ontvangen van USABC, ter waarde van één miljoen US$, voor verder onderzoek aan NiMH batterijen.

3.7 Nikkel zink

Samsung - Deze technologie is geen serieuze optie gezien de geringe levensduur van ongeveer 300 cycles. Ook door de minimale vooruitgang op dit gebied is er op de middellange termijn geen vooruitzicht voor deze technologie.

Zink-lucht

Electric Fuel Ltd. - Door het project bij de Deutsche Post, waarbij in eerste instantie 64 EV's met een zink-luchtbatterij zullen worden ingezet, is deze technologie sterk onder de aandacht gebracht. Het grote voordeel van deze batterij is z'n grote energiedichtheid die bij een redelijk batterijpakket een actieradius mogelijk maakt van meer dan 400 km. Deze actieradius maakt de voertuigen echt universeel inzetbaar en beperkt de EV niet gedwongen tot niche markten. Het zijn niet zozeer de 64 EV's die het project interessant maken als de mogelijkheid dat de Deutsche Post al zijn huidige 20.000 bestelwagens op termijn door EV's zal vervangen. Indien uit de test naar voren komt dat de EV's kosten effectief in te zetten zijn, zal het vervangen van de huidige bestelwagens door EV's vanaf 1998 plaatsvinden. Landen als Zuid Afrika, Zweden, Italië en ook Nederland gaan aan het project deelnemen. Een veelbelovende technologie met als enig nadeel het feit dat de batterij niet opgeladen kan worden maar in z'n geheel gewisseld moet worden en in een speciale opwerkingsfabriek geregenereerd moet worden. Deze opwerkingsfabrieken staan in Duitsland (Bremen) en in Italië. Voor een groot concern is het logistieke probleem van het wisselen en in voorraad hebben van de batterij niet zo'n groot nadeel, maar voor een toepassing voor particulieren op dit moment nog een struikelblok. Speciale wisselstations voor batterijen zullen hiervoor nodig zijn. Cruciaal in het gebruik van deze batterij zal zijn hoe snel het transport en de opwerking kan plaatsvinden i.v.m. de invloed op het aantal benodigde extra batterijen. Of de voordelen van een grote energiedichtheid zullen opwegen tegen de nadelen van het wisselen van de batterij is op dit moment nog niet te zeggen. De uitkomst van de proef bij de Deutsche Post zal alles bepalend zijn.

3.8 Lithium ion

De voordelen van een Li-Ion batterij zijn de volgende:
- Hoge energiedichtheid (actieradius),
- Hoge vermogensdichtheid (acceleratie),
- Lang leven (meer dan 2000 cycles),
- Laadtoestand gemakkelijk te detecteren,
- Hoge laad-ontlaad efficiency (geringe verliezen),
- Goede snellaad mogelijkheden,
- Goede lage temperatuur eigenschappen.

Geen geheugen effect (capaciteitsverlies door herhaalde geringe ontlading).

Sony - De meest veelbelovende batterijtechnologie van dit moment. In samenwerking met Nissan heeft Sony een Li-Ion batterij ontwikkeld voor toepassing in EV's. Nissan verwacht begin 1998 met een EV op de markt te komen met Li-Ion batterijen, zij zijn hiermee duidelijk verder dan de concurrentie. Saft - Heeft veel onderzoek gedaan en ze hebben ook prototypes gemaakt, maar ze verwachten geen commerciële productie van EV batterijen voor het jaar 2000. Daar waar een NiCd batterij van Saft nu een range geeft van 100 km (vier persoons EV) zal een Li-Ion batterij volgens hun verwachting een range van 200 km geven. Saft (Amerika) heeft recent een contract ontvangen van USABC, ter waarde van 1.4 miljoen US$, voor verder onderzoek aan Li-Ion batterijen.

3.9 Lithium polymeer

Dit is echt een technologie voor de lange termijn. Er is nog geen uitzicht op toepassing in de consumenten elektronica, laat staan voor EV's. De technologie is wel veelbelovend met specificaties die beter zijn dan die van Li-Ion. Daarbij zal deze batterij in elke gewenste vorm gemaakt kunnen worden wat het inpassen in het voertuig gemakkelijker zal maken.

4. ANDERE OPSLAGMETHODEN

In hoeverre deze technologieën nog nodig zijn bij het gebruik van geavanceerde batterij-technologieën is zeer de vraag. Van Li-Ion wordt nog wel eens beweerd dat deze een te geringe vermogensdichtheid heeft waardoor de batterij gedimensioneerd zou moeten worden op de benodigde acceleratie en niet op range is maar de vraag. Afgaande op de specificatie van de Li-Ion batterij van Sony kan men concluderen dat deze een vermogensdichtheid heeft die vergelijkbaar is met die van een loodaccu en dus voldoende. Hiermee is een groot deel van de noodzaak tot het ontwikkelen van supercapacitors verdwenen. Gaan we echter toch de richting op van hybride voertuigen met een kleinere batterij dan zou hiervoor weer wel een supercapacitor nodig kunnen zijn.

4.1 Vliegwielen

Er was maar één presentatie over vliegwielen. De conclusie van het verhaal was wel dat vliegwielen een haalbare optie zijn om als een supplementaire energiebron voor de hoofd energieopslag te dienen. Het kiezen van de juiste materialen en het toepassen van de juiste technologieën zijn van cruciaal belang voor het succes van energieopslagsystemen die gebruik maken van een vliegwiel. Er waren geen concrete systemen en/of voertuigen aanwezig.

4.2 Supercapaciteit

Er zijn ook op dit gebied weinig interessante ontwikkelingen te melden en op het symposium was er weinig aandacht voor deze technologie. Toepassingen worden gezien bij hybride voertuigen waar de relatief kleine batterij te weinig vermogen heeft om het voertuig een redelijke acceleratie te geven. Een andere mogelijke toepasssing is het efficiënt opslaan van remenergie. Het voordeel van supercapacitors in deze toepassing zou zijn dat ze de grote energiestromen die met het remmen gepaard gaan goed kunnen opslaan.

Een unieke ontwikkeling is die van een capacitor die de energie eigenschappen van een lood-zuur accu benadert. Op zich niet spectaculair, maar de levensduur van de capacitor is beduidend hoger. Misschien een ontwikkeling waar we meer van zullen horen.

4.3 Remenergie recuperatie

Recuperatie van remenergie is essentieel voor het halen van een acceptabele actieradius. Opslaan van remenergie geeft een actieradius vergroting van ongeveer 20-30%. Anders gezegd, recuperatie van remenergie kan energie opleveren die ongeveer 20-30% van de totaal door de batterij te leveren energie kan bedragen. Bij remrecuperatie kan je op verschillende manieren de energie opslaan. Bij batterijen heb je zeker bij de grote stromen (energieën) waar je bij remmen over praat een batterij nodig met een lage inwendige weerstand. Het zal echter niet mogelijk zijn alle remenergie te benutten en een mechanisch remsysteem zal ook nodig blijven.

Vliegwielen en ook supercapacitors zouden in staat zijn om remenergie beter om te zetten en op te slaan. Er zijn geen nieuwe ontwikkelingen te melden.

4.4 Snelladen

Ondanks dat de ervaringen met snellladen in de praktijk niet overtuigend zijn is er toch een leuke ontwikkeling van de Canadese firma Norvic Traction Inc. Deze firma heeft aangetoond dat snelladen, met hun lader, beter is voor de levensduur van de batterij en een betere benutting van de capaciteit mogelijk maakt. Tevens is de laadefficiency hoger doordat overladen wordt voorkomen. Deze voordelen zijn aangetoond voor loodzuurbatterijen. Het onderzoek aan NiCd batterijen loopt nog, maar er is al gevonden dat de effecten van snelladen niet ten koste gaan van het leven van de batterij en ook geen invloed hebben op het energiegebruik van het voertuig.

4.5 Hybriden

De meeste ontwikkeling op het gebied van hybriden richt zich nog op de bus en niet op de personenwagen. Dit komt voornamelijk door het feit dat de batterij benodigd voor een bus te groot, te zwaar en ook te duur is. Voor een bus is de hybride aandrijving een relatief goedkope manier van aandrijving. Echter, de kansen voor hybride personenenwagens nemen toe door veranderende regelgeving in Californië ten gunste van hybriden. Het probleem van het doen van uitspraken over de ontwikkeling van hybriden is dat er bijna een oneindig aantal verschillende concepten mogelijk zijn met elk weer hun specifieke voor en nadelen. Een trend die wel waarneembaar is, is dat men de concepten tot nu toe redelijk eenvoudig houdt. Voor bussen zijn de meeste concepten eenvoudige seriehybriden. Bij een seriehybride is de aandrijving altijd elektrisch. Bij een parallelhybride is de aandrijving mechanisch, indien gewenst kunnen de vermogens van de ICE en de elektromotor bij elkaar worden opgeteld door ze gelijktijdig te laten draaien. De seriehybride heeft potentieel de laagste uitlaatgasemissies doordat operatie van de ICE op een constant toerental tot de mogelijkheden behoort en deze hiervoor optimaal kan worden ontwikkeld. Hybriden zijn gecompliceerder dan batterij EV's, maar het voordeel is dat de prestaties en dan met name de actieradius kunnen toenemen en dat volstaan kan worden met een batterij van een kleinere capaciteit. In het eenvoudigste geval is de extra complexiteit die van de toevoeging van een kleine ICE met alles wat nodig is om deze te laten werken. Op dit moment zijn de kosten en het gewicht van een hybride nog hoger dan en batterij EV

4.6 Brandstofcel EV's

Een bijzondere vorm van hybride is de brandstofcel EV. Simpel gezegd is een brandstofcel een energiebron waarbij door een reactie van waterstof met zuurstof direct elektriciteit wordt opgewekt met als enige emissie water. De elektriciteit wordt opgewekt op het moment dat de elektrische belasting van bijvoorbeeld een elektromotor aanwezig is. Er is dus geen sprake van energieopslag zoals bij een batterij. Toyota presenteerde een brandstofcel versie van zijn RAV4L EV. Het bijzondere van dit voertuig was met name de methode van waterstofopslag. De waterstof was niet opgeslagen in vloeibare vorm onder hoge druk zoals bij de Mercedes Necar brandstofcelvoertuigen en ook niet bij zeer lage temperatuur. De door Toyota toegepaste waterstofopslag is door middel van een waterstof absorberend metaalhydride. Het is een nieuw type metaalhydride met een veel hoger vermogen om waterstof te binden dan reeds bekende metaalhydriden. Door deze doorbraak kon in een vrij klein volume toch voldoende waterstof opgeslagen worden voor een actieradius van 250 km. De waterstoftanks van de Necar zijn bij een gelijke actieradius vele malen groter. Er was veel belangstelling voor de Toyota en de presentaties erover. Een commercieel verkrijgbaar brandstofcelvoertuig is nog niet aan de orde, maar de potentiële voordelen zijn enorm en de ontwikkelingen, ook bij Mercedes (Daimler-Benz), gaan sneller dan men zelf oorspronkelijk had ingeschat

5. BELEID EN MARKTONDERZOEK

In het algemeen is het teleurstellend wat in de diverse landen gedaan wordt om de aanschaf van EV's te stimuleren. Als er al incentives waren zijn die nu goeddeels afgelopen. Zonder nieuwe stimuleringsmaatregelen zal de EV het niet redden gezien zijn prijs en prestatie nadeel.

5.1 Beleid

USA

Californië - Het Zero Emission Vehicle mandate van de California Air Resource Board (CARB) is recent afgezwakt. De opgegeven reden is dat er geen voertuigen beschikbaar waren op het moment van de beslissing die voor de potentiële afnemers acceptabel zouden zijn. Daarom is de 2% eis voor 1998 komen te vervallen. maar de eis dat 10% van de nieuw verkochte voertuigen in 2003 ZEV moeten zijn is onveranderd van kracht gebleven. Er is geen reden om aan de opgegeven reden te twijfelen. De uitwerking kan twee kanten opgaan. Een mogelijk gevolg zou kunnen zijn dat de ontwikkelingen van EV's nu stoppen of op een laag pitje gezet worden en dat de 10% eis op termijn ook komt te vervallen. Waarschijnlijker is toch dat vasthouden aan de 2% optie in 1998 zou hebben betekend dat er inderdaad onacceptabele voertuigen op de markt gekomen zouden zijn die de reputatie en de acceptatie van EV's zouden hebben verslechterd. Nu de automobielfabrikanten en hun toeleveranciers wat meer tijd hebben gekregen is de kans toegenomen dat er goede EV's op de markt zullen komen, met prestaties die zullen aansluiten bij de eisen van de markt. De 2% eis zou betekend hebben dat ongeveer 20.000 EV's verkocht zouden moeten worden in 1998. De aantallen die de automobiel fabrikanten nu op de markt zullen brengen zullen lager zijn, maar er zijn nog wel stimulerings maatregelen die het aantrekkelijk maken om EV's toch af te zetten en dan met name die waar baanbrekende technologie in zit zoals b.v. NiMH batterijen. Een andere interessante ontwikkeling is dat de regelgeving van het ZEV mandate aangepast zal worden zodat ook hybride voertuigen, mits ze voldoen aan zeer strenge uitlaatgasemissie eisen, ook als ZEV geteld mogen worden. De emissie eisen liggen op het niveau van 1/10 van de huidige toch al zeer strenge Ultra Low Emission Vehicle (ULEV) eis. Deze wijziging zal de ontwikkeling van hybride voertuigen bespoedigen, maar kan aan de andere kant ook ontwikkelingen voor Battery Electric Vehicles (BEV) afremmen. Het is nog te vroeg om de eventuele effecten waar te nemen. In de VS komt de koper van een EV voor een belastingteruggave in aanmerking van maximaal $5000. Hoe het bij de lease van een EV zal gaan is op dit moment nog niet duidelijk.

Zwitserland

In Mendrisio is in 1995 een pilot project voor de introductie van LEVs (Light Electric Vehicles) gestart. De doel van dit programma is het onderzoeken, in een kleine gemeente, wat de effecten van de vervanging van 8% van de conventionele voertuigen in Zwitserland door EV's zou zijn. Op dit moment is 1% van de voertuigen in Mendrisio een EV en in het jaar 2000 moet dit percentage 8% zijn, en daarmee representatief voor de situatie die men voor heel Zwitserland wil bereiken. Er zijn op dit moment ongeveer 20 verschillende type EV's te koop, waarbij de ongeveer de helft van het aankoopbedrag gesubsidieerd is. De EV's zijn voornamelijk door particulieren en bedrijven gekocht.

Frankrijk
Parijs - Een van de weinige steden waar daadwerkelijk maatregelen genomen zijn om het gebruik van EV's te stimuleren middels gratis parkeren en het tegelijkertijd bieden van infrastructuur voor het opladen van de batterij.

Japan
Osaka - Er zijn proeven met in totaal ongeveer 160 EV's geweest, maar de projecten zijn min of meer afgelopen en het gebruik van de EV's is aan het afnemen. De financiële stimulerings-maatregelen zijn ook afgelopen en vervolgprojecten zijn er nog niet.

5.2 Marktonderzoek

USA
De Ford Motor Company is in december 1994 gestart met de 'Ford Ecostar Customer Drive Program' om de marktkansen van hun Ecostar (EV), met een range van 160 km, te kunnen evalueren aan de hand van het gebruik van het voertuig in de praktijk door een potentiële doelgroep.

De studie heeft de volgende bevindingen opgeleverd:
De prestaties van de Ecostar werden als positief ervaren. De actieradius van 160 km werd als voldoende ervaren voor vaste trips als woon-werk verkeer. Het één keer per dag thuis opladen was geen probleem. Oudere deelnemers gebruikten de Ecostar minder en waren minder bereid een EV te kopen. 76% van de gebruikers waren geïnteresseerd om een competitief geprijsde EV met een range van 160 km te kopen.

Californië
Een studie onder 454 'multicar' huishoudens in Californië, waarbij van te voren informatie over het gebruik van EV's over het laden en andere zaken was gegeven, resulteerde in een positieve respons. Veel huishoudens waren bereid zich aan te passen aan de beperkte actieradius van een EV en de mogelijkheid om thuis te kunnen bijladen werd heel aantrekkelijk gevonden. Een significant markt potentieel werd gevonden bij deze huishoudens.

Europa
Een onderzoek naar de marktsegmenten in Europa voor elektrische voertuigen heeft opgeleverd dat ze klein zijn, maar in ontwikkeling. In de meeste landen worden EV's alleen gebruikt in demonstratie en testprojecten. Als belangrijkste redenen voor deze beperkte inzet wordt gegeven de hoge initiële prijs van EV's en het ontbreken van informatie over EV's.

Frankrijk
In Frankrijk is een marktstudie uitgevoerd op basis van opinies over EV's in diverse media publicaties die verschenen zijn sinds 1992. Door deze studie is een goed beeld

verkregen van de publieke opinie over EV's aangezien die vooral door deze publicaties is gevormd. Het beeld dat over EV's naar voren komt was in eerste instantie niet geweldig, maar naarmate we bij artikelen van recentere datum komen is de situatie progressief verbeterd. De EV van vandaag komt naar voren als een voertuig die een goede ontwikkeling doormaakt en die (in de stad) grote voordelen biedt. De EV heeft een image gekregen van een ideaal voertuig voor kleine woongemeenschappen en bedrijven. Waar we volgens de onderzoekers voor op moeten passen is dat deze visie de overhand krijgt. De EV moet iets uit blijven stralen van datgene waar dromen van gemaakt zijn en een toegevoegde waarde hebben die de publieke opinie positief zal beïnvloeden.

6. RANDVOORWAARDEN INFRASTRUCTUUR

Japan

Osaka - Voor de proeven met EV's heeft men in Osaka op 10 strategische plaatsen in de stad snellaadstations geplaatst die echter tijdens de proeven weinig werden gebruikt. Voor het gebruik van deze voorziening moest worden betaald, wat tot het lage gebruik zal hebben bijgedragen. De gebruikers gaven er duidelijk de voorkeur aan om de batterijen tijdens de nacht te laden. Het voordeel van een grotere actieradius of de mogelijkheid om meer km's per dag af te leggen woog niet op tegen de nadelen.

Duitsland

In Duitsland staan 100 oplaadstations (januari 1996) voor het opladen van EV's. Er is geen specifieke wetgeving aangaande deze stations, maar bestaande wetgeving kan de introductie toch bevorderen. De 100 oplaadstations zijn geplaatst door stadsgemeentes, bedrijven en particulieren. In veel gevallen (>50%) werd de installatie mogelijk gemaakt door programma's voor de installatie van zonnepanelen. De energie van de zonnepanelen wordt aan het elektriciteitsnet geleverd en niet direct aan de voertuigen. Bij soortgelijke projecten in de VS is dit ook zo gedaan. Dit is gedaan vanwege de verschillen tussen vraag en aanbod van de energie. Over specifieke ervaringen met deze stations was op het symposium geen informatie beschikbaar. De installatie van de stations heeft geen grote technische problemen opgeleverd; soms was er wel sprake van administratieve (ambtelijke) problemen. Er zijn een beperkt aantal snellaadstations maar deze worden zeer weinig gebruikt, zoals praktijkproeven in o.a. Rügen hebben aangetoond. De aanwezigheid van snellaadstations gaf de gebruikers wel een gevoel van zekerheid voor eventuele noodsituaties (lege accu).

Een andere Duitse studie (van een batterijfabrikant) gaf aan dat beter batterijen met een grotere capaciteit konden worden geïnstalleerd dan het aanleggen van dure snellaadstations. Het is goedkoper en gemakkelijker om een batterij te installeren die een grote actieradius mogelijk maakt dan snellaadstations aan te leggen die zelden op het juiste ogenblik op de juiste plek staan. Mobiele noodlaadstations werden voorgesteld als een alternatieve oplossing.

Een studie van de RWE ging in op de gevolgen van grootschalige inzet van EV's op de elektriciteitsvoorziening. Zelfs voor 10 miljoen EV's (ongeveer 20% van de bestaande ICE vloot) kan het bestaande elektriciteitsnet de energie leveren mits de EV's 's nachts worden opgeladen. Van deze 10 miljoen voertuigen kan 1 miljoen zonder problemen ook overdag worden geladen. Gezien de gemiddelde afstand die nu in Duitsland met ICE voertuigen wordt gereden is er geen commerciële basis om snellaadstations voor EV's aan te leggen. 95% van alle ritten is namelijk korter dan 50 km.

Zwitserland

Een uitgebreide studie naar de kosten voor de infrastructuur voor EV's heeft de volgende getallen opgeleverd. Voor nachtladen US$ 800 per station, voor laden overdag US$ 1500 en voor laden bij een parkeerplaats US$ 4000 per station. De bedragen zijn in 1996 US$ en er is uitgegaan van optimistische aannames als eenvoudige stations met eenvoudige betalingssystemen en van een groot aantal geproduceerde stations.

7. MARKTINTRODUCTIESTRATEGIEEN

De General Motors EV1 zal als hij in december 1996 op de markt komt niet te koop zijn, maar alleen geleasd kunnen worden op basis van een nieuwprijs van $33.995. Dit is mogelijk gedaan vanwege de in de VS mogelijke grote financiële claims van particulieren als ze een product hebben gekocht dat niet aan de gewekte verwachtingen heeft voldaan. Maar wat waarschijnlijker is dat men bij GM een betere controle over het product wil hebben, zodat men b.v. de voertuigen met een nieuwe batterij (NiMH van Ovonics) kunnen uitrusten als het hun goed uitkomt. De GM EV1 zal in het begin alleen in Arizona en Californië verkrijgbaar zijn, naar men zegt vanwege de ongeschiktheid (afname capaciteit) van de gebruikte batterij-technologie om in koude (winterse) gebieden te opereren (beneden 0°C). Voor latere versies met NiMH batterijen zal deze beperking mogelijk niet meer gelden. GM zegt dat ze alle bestellingen zullen honoreren, maar wil zich niet aan verkoopprognoses wagen. Verder is het opvallend dat de EV1 met een General Motors badge door het leven zal gaan en niet onder een van de vele GM merknamen. Het is redelijk uniek dat dit zo is gedaan. De marketing, verkoop en after sales zal allemaal door de Saturn organisatie worden gedaan. Dit is een GM organisatie met een zeer goede reputatie, die onder de Saturn merknaam in de VS auto's op de markt brengt.

8. NAWOORD

EVS-13 was vooral een technisch georiënteerd symposium met heel weinig aandacht voor onderwerpen als beleidszaken, marktintroductiestrategieën, regelgeving en milieu. Zoals het aantal presentaties over het onderwerp batterijen wel duidelijk maakt is dit het cruciale onderdeel in de hele EV ontwikkeling. Loodzuurbatterijen hebben voor de gerenommeerde automobielfabrikanten geen toekomst gezien de lage energiedichtheden maar vooral gezien de korte levensduur van ongeveer 500 ontladingen. Of deze batterijtechnologie het daarom vanuit een kostenoogpunt nog lang kan volhouden is de vraag. De toekomst is duidelijk aan de geavanceerde batterijen. Spectaculaire ontwikkelingen zijn er op EVS-13 niet gemeld, niet op het gebied van batterijen maar ook niet op andere gebieden.

EVS-14 zal worden gehouden van 15-17 December 1997 in Orlando, Florida, USA.

BIJLAGE: Beperkte selectie symposium verhalen

Electricity Supply of Electric Vehicles in Germany

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ABSTRACT: As air pollution increases there is a growing interest in the use of electric vehicles. Legislation in California has provided a new incentive to the development of electric vehicles, which are in the early stage of introduction to the market in many parts of the world, including Germany. In Germany the electricity supply system has the capacity to supply electric vehicle demand in the near future without any changes. The impact of electric vehicles on electricity generation is very small; the substitution of 5 % of existing vehicles by electric vehicles would result in an increase of demand for generation of only 1 %.
Statistics of the current use of conventional passenger cars give useful information for the needed infrastructure for electric vehicles. Caused by the very small impact of electric vehicles on the supply system, the charging infrastructure must fit to the existing system. The German electricity supply system offers sufficient power for charging at home. There is no need for a fast charging infrastructure for private passenger cars.

1. Introduction

Growing air pollution, especially in major urban areas, means that new solutions must be found to reduce pollutant levels in road traffic as well. As the Californian example shows, the introduction of catalytic converters in cars since the mid-1970s has not sufficed to meet local clean air targets. This being so, legislation now calls for the introduction of "zero-emission vehicles", i.e. vehicles that are emission-free at the point of use.

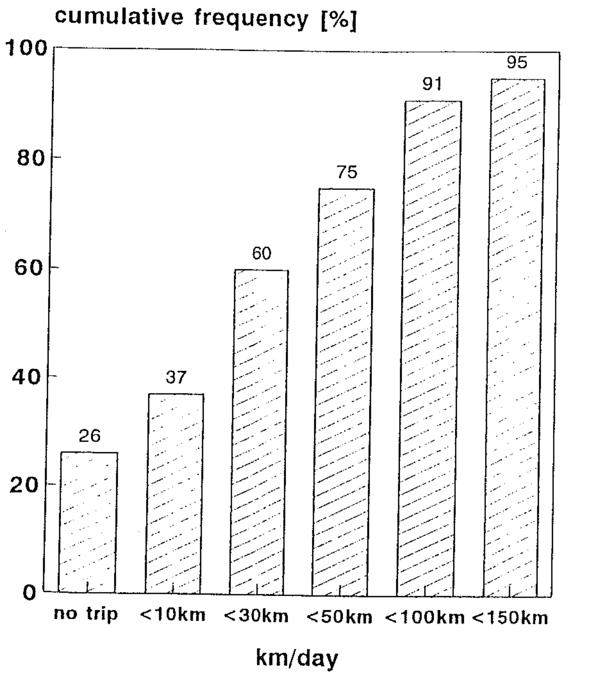
If we transmit California's clean air aims to Europe and, hence, to Germany, comparable steps must be expected here as well. With the state of knowledge available today, the only feasible zero-emission vehicles are battery powered electric vehicles.

As an infrastructure already exists for electric vehicles, no new infrastructure of a supply system is necessary to provide the power needed. The following is an account of how electric vehicles can be accommodated in large numbers by Germany's existing electricity supply system.

Although we have had the reunification of the electricity supply system in Germany since September this year, the old states are considered only. The electricity supply system in the new federal states is changing so much, that all statements related to the new states made today are only valid a short period of time. Caused by the amount of produced electricity in the old and new states of Germany - the total net production was 422 TWh, 366 in the old and 56 in the new states in the year 1994 - the German electricity supply system is dominated by the old states of Germany.

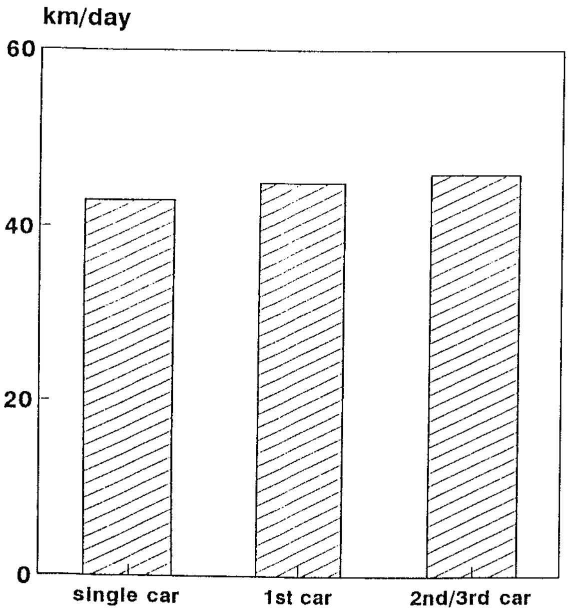
2. Statistics of the use of passenger cars in Germany

It is important to know the driving statistics of conventional cars to assume the impact of a big number of EVs on the electricity supply system. If big numbers are considered, passenger cars can be considered only. Fig. 1 shows the daily mileage of passenger cars in Germany.



Source: IVT

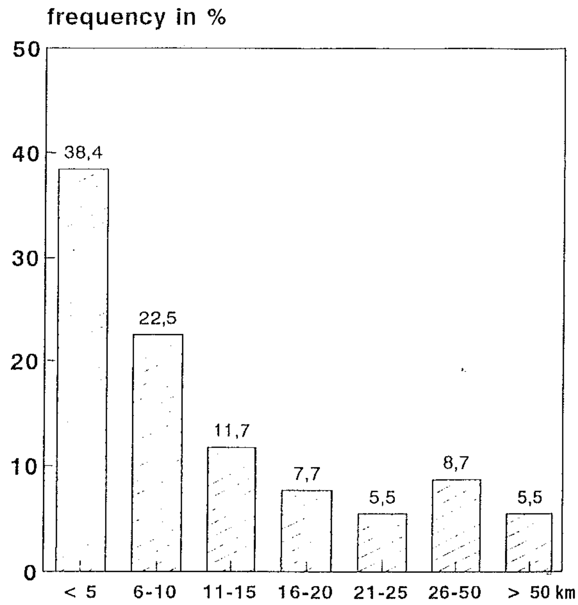
Figure 1 Daily mileage of passenger cars in Germany



Source: IVT

Figure 2 Average daily mileage of German cars as single, first, second or third car

Fig. 2 shows the average use of passenger cars as single, first, second or third car in Germany. The differences in the use of a car as the first, second or third car are small, so the total population can be considered to get results based on statistics.



source

Figure 3 Trip lengths of passenger cars in Germany

In Germany the average daily mileage of all passenger cars is 43 km. If we consider EVs, daily mileages beyond 150 km are not taken into account due to the fact that the total range wouldn't be used, the average mileage of EVs is 30 km per day.

If we look at the distribution of the trip lengths in Germany, we find that more than 95 % of all trips are shorter than 50 km (back trip included). Fig. 3 shows the distribution of the trip lengths of passenger cars in Germany. The low average of daily mileage and the very seldom long trip lengths help to introduce EVs in Germany.

3. Supply of energy and power

Based on these data a study sponsored by the minister of transport (1) shows a theoretical potential of up to 9 million electric cars in the old states of Germany, almost all second or third cars. This is about 20 % of all cars in Germany.

With a mean mileage of 30 km/day equivalent to 11000 km/year the total electric energy required amounts to about 22 TWh for 10 million EVs, if an average energy consumption of 20 kWh/100 km is assumed. This is about 5 % of the net electricity production in Germany.

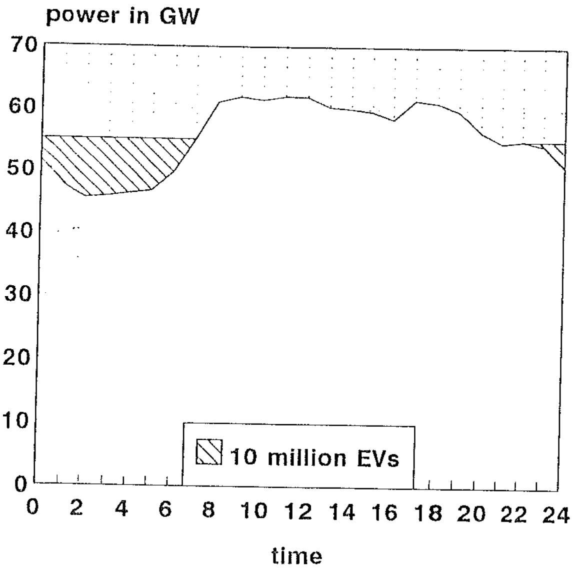


Figure 4 Power demand at the winter peak of the year 1990 with 10 million EVs

Electric energy cannot be stored on a commercial scale. This means that power supply systems must provide the electricity at the same time as it is needed by customers. Storage power stations, storing energy almost entirely in the form of potential water energy, have less than a 2 % share in the electricity provided on a max. load day in the old federal states, so they are left out of account here.

The differences in usage for various electrical appliances generally produce curves for total power demand in Western Germany for a typical winter peak day as shown in Fig. 4.

10 million EVs would not have filled the night valley up to 50 % at the winter peak day in the old states of Germany. It is assumed that all passenger cars are charged at night. If up to 10 % are charged during the day, the following considerations are still valid. It is clear that even for 10 million EVs electricity can still be supplied without any need for new power plant capacity even if other electricity applications are relocated into the night.

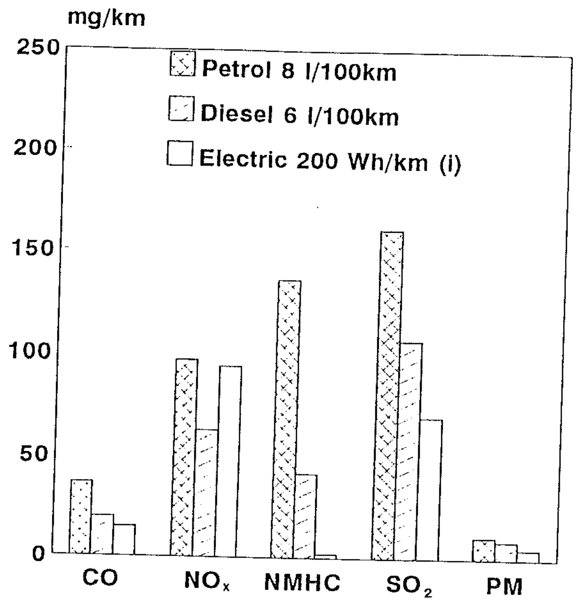
From the electricity generation's point of view the power of the charger for charging the battery of an EV is of minor importance. As the total electricity demand of a big number of EVs is about constant at all days of the year, the power of the charger can vary in a wide range, if the time of switching on is dispersed by special means of the utilities. The power of the charger is limited by restrictions of the local net work, only.

4. Emissions related to EVs

In the next decade the number of EVs in Germany will be much lower than 10 million cars. Optimistic forecasts e.g. from Shell expect 1.2 million electric cars for the year 2010 (2). This figure would require about 0.6 % of the total electricity production of Germany.

These ratios must be kept in mind when primary energies and the emission of pollutants and/or gases affecting the climate are attributed to the electric car. Since the electric car is exhaust-free at the point of use, emissions can only be caused by the electricity generation.

If specific primary energy sources are to be identified with specific applications, we need a quantitative breakdown of power generated by the various power plant types. Although the amount of electricity required by an appliance can be exactly measured, a definite physical attribution to a particular power plant is not possible in a meshed network. This being so, models must be employed.



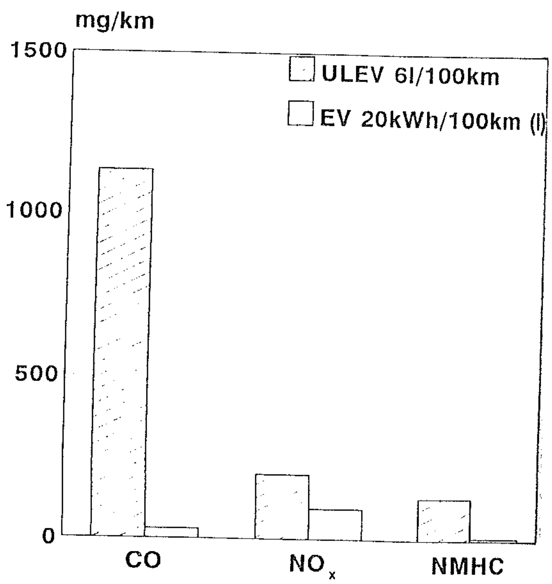
(i) Electricity Generation West-Germany 1994

Figure 5 Air pollutant emissions of final energy preparation (3, 4)

One attribution rule often found, especially in new power applications, is the incremental approach. This involves an attempt to assign the extra power generated to all new applications. However, when different power plant types are assigned to specific power applications, this leads to insoluble contradictions. An incremental view requires fixed deadlines. This means that the appliances or user groups in existence at a certain point of time are assessed differently from those added after that time.

For example, different power plants would be postulated for the operation of two identical microwave units, depending on when they were first used. The same would apply to accounting units, e.g. households. As from a certain point in time, any new household would be regarded as an increment. Since other households are being wound up at about the same time, however, the attribution of an incremental or decremental quantity of power to specific households is impossible.

If this were applied to the electric car, it would mean that existing electric vehicles - some 4,500 in the year 1994 in Germany - would have a different environmental compatibility than new cars being added. We would also have to decide, e.g., how to attribute power plant capacity made available by the use of energy-saving household appliances to other electricity applications.



(i) Electricity Generation West-Germany 1994

Figure 6 Global air pollutant emissions of ultra low emission vehicles and electric vehicles in Germany

Since this cannot be solved for specific cases, the principle of equality must be employed: all applications are divided equally between all power plants in the system. What must be considered, however, is the time when the electricity is used. At night, for example, power is generated with a different primary energy mix than during the day. The equality principle also underlies accounting practice, which, for the reasons described earlier, cannot charge incremental costs merely for new applications, although the actual time of use is certainly taken into consideration. But this difference hardly influences the emissions of EVs. Because the differences in using the annual mix or the night mix are quite small about 5 %, the annual mix including day and night is used only.

The consideration based on the electricity generation mix is still applicable on a national basis, when customers can choose their own supply company. The average behaviour of EV customers must be the same as the bahivour of all customers in that case, of course.

Based on these considerations the air pollutant emissions of the electricity production for electric vehicles are compared to the emissions of petrol and diesel preparation (Fig. 5).

In West Germany only 45 % of electricity production is free of exhaust, 55 % is based on fossil fuel with very effective flue gas cleaning. The air pollutant emissions of electricity production for EVs are at the same magnitude like the one of diesel and petrol preparation. If engine emissions are included even on an ULEV level, electric vehicles in West Germany offer a big reduction of air pollutant emissions not only on the local but at the global level, as shown in Fig. 6.

5. The charging of an EV

If we compare the refuel time of conventional vehicles and EVs, we see very big differences. Fig. 7 shows the refuelling speed in km range per minute for petrol, diesel and different power levels of battery chargers. Even for an electric power level of 120 kW the refuel speed of diesel is about 50 times higher. This means that an EV driver must spend between 30 and 70 times more time at a refuelling station for the same mileage. This means, that the average time per month for refuelling a conventional passenger car is less than 5 minutes. An EV driver must stay at a fast charging station of 100 kW power more than 2 hours for the same mileage of about 1000 km per month.

Because fuelling a vehicle is not the most interesting undertaking people would not like to spend time at a special charging station for EVs. The consequence of that must be to charge the EV at the place where it is parked and not to drive the EV to a refuelling station. Special charging stations will probably be used in emergency cases only by private EV users.

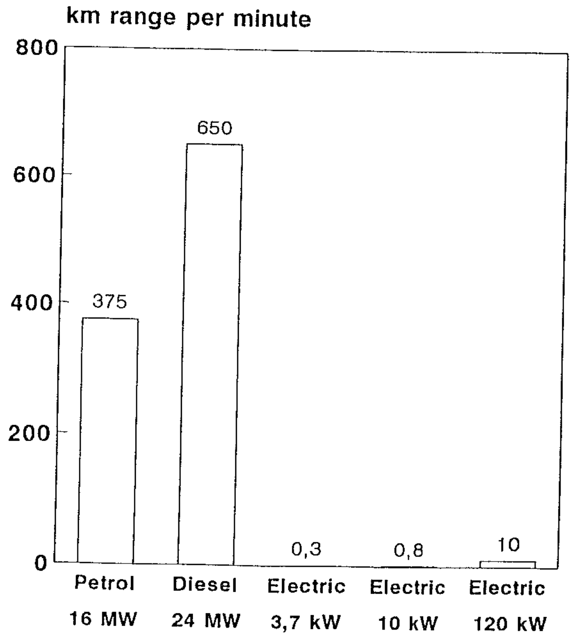


Figure 7 Refuelling speed for a compact-car with different drives

There is another aspect against special charging stations for EVs. The distribution of daily mileage shows, that there is only a small percentage of vehicles, which really could need quick charging. The demand for quick charging depends on the range per charge. Fig. 8 shows the theoretical demand for rapid recharging depending on the range per charge, if quick charging would double the daily mileage. If EVs would have a range per charge of 150 km, the theoretical demand for quick charging to double the daily mileage is less than 3 %. So the commercial basis for the use of special charging stations is very small. In addition the electricity at quick charging stations must be more expensive, which will reduce the use of this refuelling offer additionally. In Germany each petrol refuelling point supplies about 600 vehicles. The average using time per year is about 300 h. With the same using time of a quick charging station for EVs only 15 electric vehicles could be served. This would require much more quick charging stations for a certain number of EVs than we have refuelling points for the same number of i.c. engined vehicles. Therefore the infrastructure costs of quick charging per EV with the same level of comfort like the petrol supply would be very high.

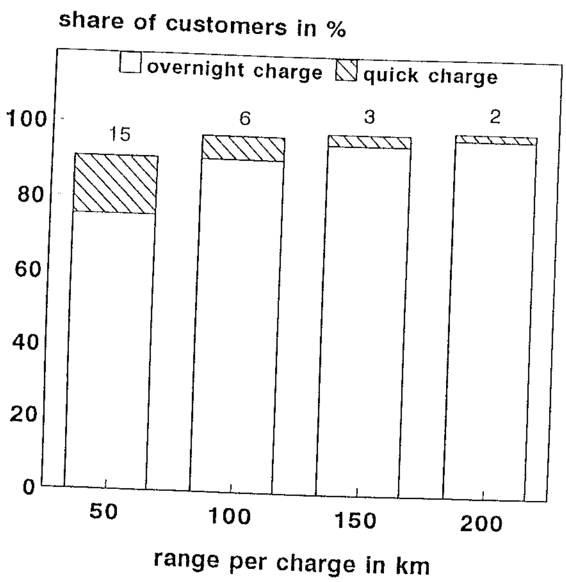


Figure 8 Shares of potential customers for quick charging by doubling the daily mileage using quick charging

Of course this is not true for special commercial EV applications like vans, taxis etc.. For these vehicles rapid recharging could be an interesting solution. The most likely way of charging of passenger cars will be charging at the placed where the EV is parked during night.

6. Charging facilities at home in Germany

Because charging at home will be the most likely way of recharging a battery of an EV, the facilities available in Germany shall be considered. Table 1 shows the standardised grid connections available in Germany.

Table 2 shows the charging time for 30 km or the range charged in 6 h, which is the minimum off peak tariff time.

Voltage	current	power
230 V/1 phase	10 A	2,3 kW
230 V/1 phase	16 A	3,6 kW
400 V/3 phase	16 A	11 kW
400 V/3 phase	32 A	22 kW

Table 1 Grid connections in Germany

power	charging time[i] for 30 km	theoretical range in 6 h[i]
2 kW	3 h	60 km
3 kW	2 h	90 km
10 kW	40 min	300 km
20 kW	20 min	600 km

(i) energy consumption 20 kWh/100 km

Table 2 Charging times and theoretical ranges for different grid connections in Germany

As boilers for warm water with a power of up to 24 kW are allowed in many parts of Germany, the power of a charger of an EV could be also in the same range. This power would allow to recharge the battery for an average daily use of about 30 km in 20 minutes. Of course special rules must be taken into account, for example a device must be installed which forbids the use of a boiler and a charger at the same time. So during off peak tariff time chargers up to 24 kW could be allowed in many parts of Germany caused by the high power capability of the German distribution grid, but for almost all applications 3 to 7 kW as the power of an on board charger is sufficient.

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FORD ECOSTAR MARKET RESEARCH

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Abstract: The Ecostar Customer Evaluation Program was implemented to place the first electric vehicle (EV) with a 100 mile range and competitive performance in the hands of a representative sample of California retail customers. The major findings include:

1. Performance - very favorable overall
2. Range - A 100 mile range EV was a direct replacement for fixed trips such as work and school
3. Recharging - conductive home charging once a day was acceptable
4. Demographics - the older participants used the EV less and were less willing to purchase an EV
5. Purchase - approximately 76% interest in owning a competitively priced 100 mile range EV.

1.0 PROGRAM OBJECTIVES

Ford Motor Company implemented the Ford Ecostar Customer Drive Program in December 1994 to evaluate the reaction of retail consumers to "owning" an advanced electric vehicle (EV) with 100 mile driving range in typical driving conditions. Southern California Edison (SCE) and Los Angeles Department of Water and Power (DWP) participated as the utility partners. The ownership period for each customer was two weeks. The program was designed to learn about customer acceptance of an EV in real world driving conditions. Ford Motor Company is currently using this "voice of the customer" information in the design and development of future electric vehicles. The specific feedback objectives included:

- Use of an EV with a 100 mile range as a personal vehicle
- Participant travel and vehicle range variables
- Perceptions on range and recharging issues
- Reaction to "owning " an EV (based on two week drive experience)
- Purchase consideration of an EV

1.1 Selection Of Participants Seventy five participant households were selected from the University of California, Institute of Transportation Studies (ITS), 1994 California Household Vehicle Transactions Panel Study , and from individuals identified by the utility partners and Ford. The selection of participants from more than 500 names provided a representative cross-section of households to allow some projection to the population. The primary selection criteria were interest and the availability of a 240 Volt, 30 Ampere circuit to charge the vehicle in the garage. Commuting distances were not used as selection criteria so that the travel data collected would not be biased.

1.2 Data Collection Process The program used the following methods to gather data: (1) Ecostar's Diagnostic Data Logger Module (DDLM) provided vehicle use and performance information, (2) travel diaries provided specific trip information for both the participant's gas vehicle and that of the Ecostar, (3) pre- and post-trial attitude surveys obtained participant perceptions on range and recharging issues, and (4) post-trial interviews were video recorded to obtain specific customer reaction to general marketing questions.

2.0 USE OF AN EV WITH A 100 MILE RANGE AS A PERSONAL VEHICLE

Over 140 drivers from the selected households completed 5,747 individual trips, and traveled 40,000 miles, over a total of 1,117 days. The average mileage per 2 week trial was 540 miles. Figure 1 provides a histogram to show idle and speed ranges for the Ecostars while the vehicle was energized. The vehicles were at idle 30% of the time. The peak driving speed category was between .1 and 10 miles per hour (mph); also, the Ecostars most commonly traveled at speeds under 40 mph. Freeway speeds of 50 mph and greater were traveled 14% of the time.

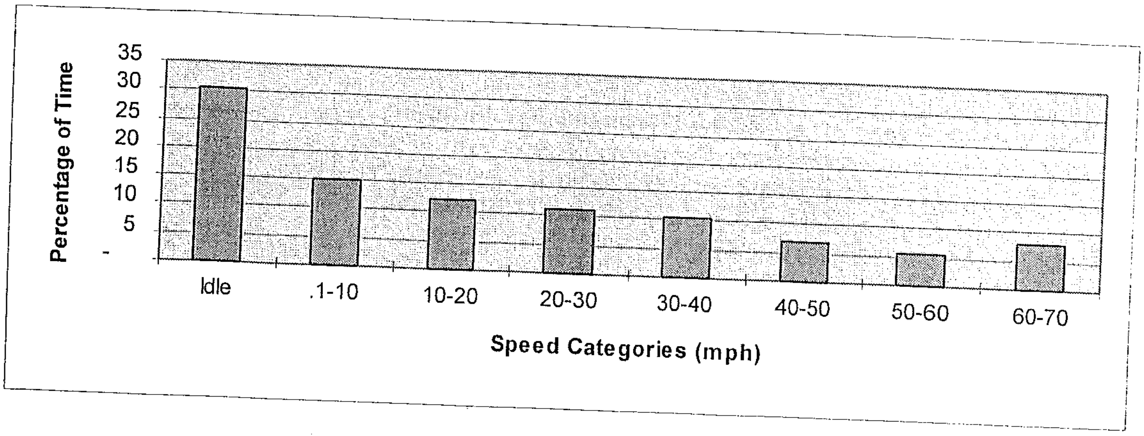

Figure 1 Idle and speed range distribution

These are typical modes for urban travel due to congestion, and is a mode where EV characteristics of no tailpipe emissions and no engine noise are among the most desirable characteristics. Minor vehicle problems were experienced on 19% of the trials, stranding three participants on the road. These were primarily related to vehicle software development problems in the early stages of the program. Vehicle problems were dealt with effectively and did not influence the resulting data.

The participants used a low-cost Hubbell Power Port conductive charger to accomplish 1,111 charging operations. The majority of charging was accomplished at the household in the evening. There were no safety issues or complaints on using this equipment. On average, the Ecostars were charged once a day, and traveled 33 miles between each recharge. A similar program that used the GM Impact vehicles (with approximately 50 - 70 miles of range) reported that participants traveled 15.2 miles between each recharge and recharged an average of 2.8 times/day as reported in Brodt[1], *et al.*(1995). This comparison demonstrates that an EV with 100 miles range is capable of reducing the need for supplemental daytime charging.

3.0 TRAVEL DATA

3.1 Participant Travel Limited range is the chief functional disadvantage of all current EVs, and a prime objective of this project was to gain an understanding o how well the 100 mile range Ecostar could replace gasoline vehicles. A comparison of the participants' travel in both their gasoline vehicles and Ecostars was accomplished using travel diary information recorded. by the participants, as reported in [2] Golob, *et al.* (1996) The travel diaries were used to record each trip purpose (such as work, errands, etc.) and the mileage. The data includes 2,099 gas vehicle trips (recorded for a one week period per trial) and 4,567 Ecostar trips (recorded for the two week trial period).

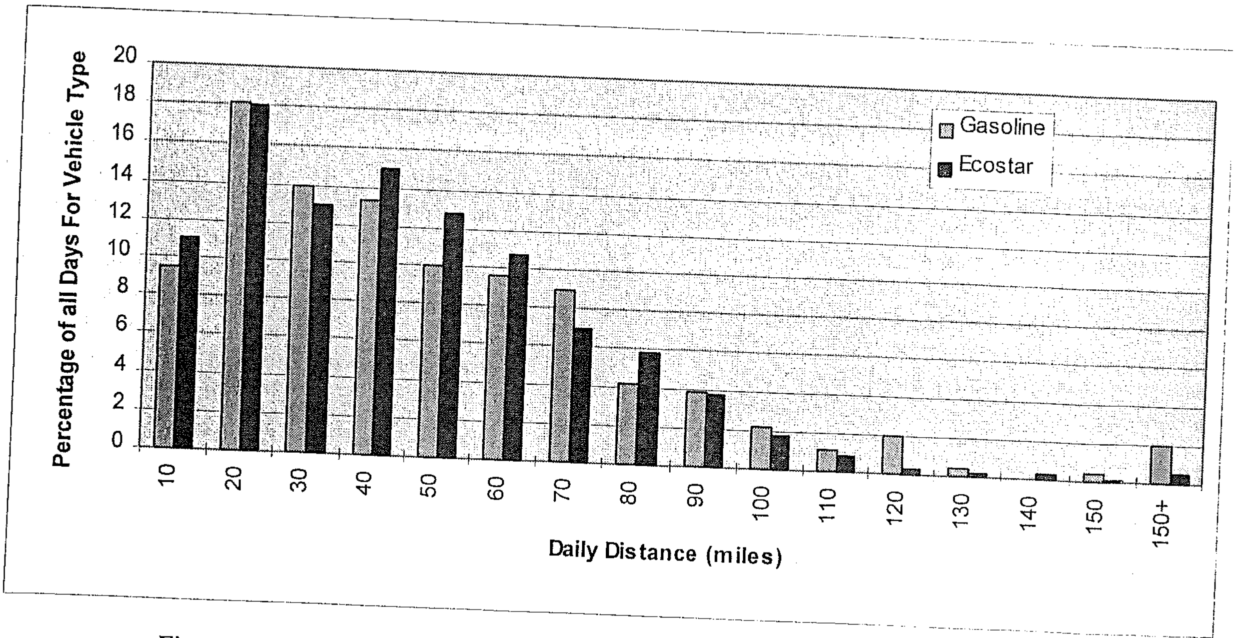

Figure 2 Distances per day for gasoline and Ecostar vehicles (in 10 mile categories)

When travel between the gasoline and Ecostar vehicles was compared, it was found that the mean distance of the gasoline vehicles was 10.8 miles per trip, and for the Ecostar 9.2 miles per trip, while the mean daily distance for the gasoline vehicles was 44 miles per day, and for the Ecostar 41 miles per day. Categorized distances for the two vehicle types are graphed in Figure 2. As expected, the distribution for gasoline vehicles had more days of 150 miles or more. To understand where the usage was different, the purpose of trips was compared with trip distances. The data divided into two general groups, trips having fixed destinations such as "work, errands, child care, medical/dental, and school" and trip destinations that were more variable such as "work-related trips" and "social and recreational trips". The most significant difference between the gasoline vehicles and Ecostar was for days that involve the variable "social and/or recreational trips". For such days the mean difference was almost six miles or about 12%. This finding indicates that the Ecostar drivers restricted themselves in their choice of destinations for social or recreational purposes, or they were restricted in the number of social and recreational destinations they could visit on a single day. When demographic variables were evaluated on a trial by trial basis, the difference was greater among the older participants.

It is to be expected that the relatively small difference between Ecostar and gasoline vehicle travel would be reduced as the drivers gained experience with the nuances of vehicle range. Participants were conservative in their perception of the state of battery discharge until they learned how the gauges worked, how the vehicle performed under different levels of discharge, and until they made their own assessments of the reliability of the information they were receiving. As a correlation to the above data, information from the Ecostars' data showed that the participants, on average, used less than half of the 100 mile range capability of the Ecostar. The mean mileage between each recharge was less than 40 miles, only a limited number of trips were taken with the battery in its lower state of charge (SOC). With the exception of a few days, the participants elected not to drive the Ecostar near its maximum range. The program that used the GM Impact reported similar results in that participants only traveled 6% of the time at low SOC as reported in Brodt, *et al* (1995). If opportunity and/or fast charging infrastructure become available to either cover the longer distance driving requirements, or relieve the driver's fear of being stranded, the differences identified by this study might be reduced. The data also showed that the participants were willing and able to substitute their longer-range gasoline vehicle for the longer trips.

3.2 Perceptions About Longer Trips Participants were asked in pre-trial and again in post-trial surveys how they would cope with longer trips beyond the range of the EV, such as a 150 mile trip. In Table 1, responses were compared from the 1994 Transportation Panel Study, which used 120 miles as a longer trip, with the pre- and post-trial surveys. The questions in all the surveys were similar except for "service station" recharging. In the Ecostar trials, participants were given considerable detail about this and it was presented as an inconvenient and expensive alternative. The data showed that most respondents would resort to vehicle-switching (make the same trip in another household vehicle). This result held even when an adjustment was made for single vehicle households. Among all participants, 69% to 79% reported making the same trip in one of their other household vehicles.

The difference between the transportation panel study and the trial participants was noteworthy: in the transportation panel, the respondents did not have direct experience, and imagined a wide set of choices. They tended to overestimate their use of options, like recharging en route, or seeking alternative means of transportation. They were also more likely to say they would rent a car, or borrow a friends car. These options were not selected, once people had actual experience with an EV.

Table 1 Decision making for longer trips using an electric vehicle

Q. What would have been done regarding the last trip if the trip exceeded the range of the electric vehicle?	Transportation Panel: Longer trip = 120 miles	Ecostar Pre-Trial: Longer trip = 150 miles	Ecostar Post -Trial: Longer trip = 150 miles
1. Cancel the trip	3%	2%	0
2. Make a shorter trip	.5%	4%	6%
3. Make the same trip in one of your other vehicles	36%	69%	79%
4. Borrow a friend's vehicle	2%	0	0
5. Ride with someone else	4%	0	0
6. Rent a car	9%	4%	2%
7. Take a train, bus, shuttle, taxi, other	4%	2%	0
8. Recharge the electric vehicle at a service station (en route)	26%	18%	10%
9. Recharge the electric vehicle while parked at or near destination	8%	NA	NA
10. Recharge at a friend or relative's house	6%	NA	NA

3.3 Perceptions About Recharging Participants were also asked in survey questionnaires how they would cope with recharging their EV. The use of the EV for longer trips was not separate from the considerations of public charging infrastructure, its convenience, availability, and fuel cost. Opinions towards the longer trips might have varied if it had been possible to get a recharge as quickly and as cheaply as gasoline tank refill. In the survey, Ecostar drivers had to envision a future scenario, where recharging was readily available at different locations. The survey item read:

> ***Recharge stations for electric vehicles are not widely available to the public today, but they might be in the future...assume that recharge stations are widely available but the cost of recharging at them is more expensive... Where would you like to recharge your electric vehicle? It would take 3 hours to get a full recharge(90 miles) or 1 hour for a partial recharge (50 miles).***

A list of possible recharging sites was given, and participants gave a yes/no response to indicate how frequently they would choose it. Figure 3 shows that with trial experience, work-sites were a preferred location for recharging stations. The percentage interested in recharging at work 'sometimes' increased from 47% to 64%. Recharging at shopping and recreational centers also gained with trial experience. Service stations were rated as less desirable, probably because the scenario envisioned spending 60 minutes at the station to gain a 30 mile increment. Recharging at transit stations was seldom chosen, probably because mass transit was not used by any of the participants in this study.

The increase in desired charging at shopping and recreational sites corroborated findings from the analysis of travel-diaries. The travel-diaries revealed that respondents used their vehicles less often for trips that were social and recreational. These destinations may have been further away, and required greater range. Since recharging opportunities were not available, this may have curtailed use of the vehicle. In the absence of recharging infrastructure, participants avoided travel to areas that they felt were too far for the available (or perceived) range of the Ecostar.

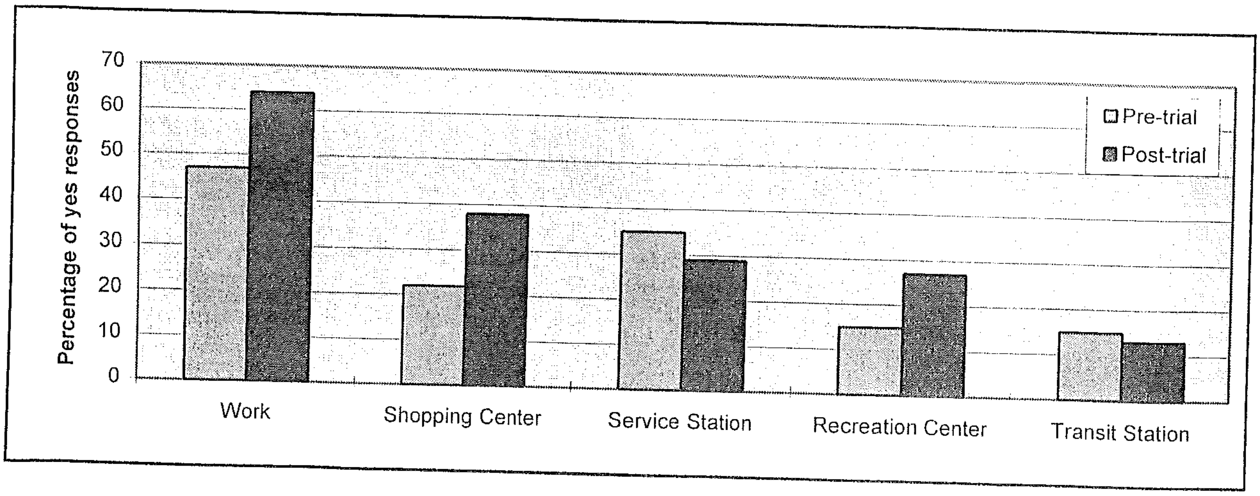

Figure 3 Preferred charging sites

4.0 REACTION TO "OWNING " AN EV FOR TWO WEEKS

At the end of each vehicle trial the Ford coordinator conducted a videotaped interview with the participant(s). The participants were asked to respond to a series of questions as if they were contemplating the purchase of an EV similar in performance and quality to the Ecostar. The video interviews were transcribed into a series of short comments and statements for each interview question. The recorded statements and comments were categorized and then coded with an identifier to allow classification and analysis of common threads and trends from the input. Some of the questions were interrelated and in these cases the data was combined.

4.1 Comments Specific to the Ecostar Vehicle

Questions 1 and 7 invoked similar responses concerning reaction to "owning" an Ecostar for two weeks, so this data was combined for evaluation purposes. The questions were:

Q1. Now that you have driven the Ecostar in daily use, what do you see as the outstanding differences between your car(s) and Ecostar?

Q7. Do you have some specific comments about the Ecostar vehicle?

Data from these questions provided 456 specific comments. These divide into two separate sets of inputs: the positive comments comprised 86% of the data, and the negative comments 14%. Table 2 summarizes the responses.

4.1.1 Positive comments The majority of the positive comments centered around the performance, handling, and quiet operation of the vehicle and how they enjoyed driving it. These groups of comments constituted 52% of all comments made and shows that people were very satisfied with the vehicle. This demonstrated that the unique characteristics of an EV, such as good initial acceleration and quiet operation, would be strong selling points when EVs came to the market:

"The handling was better; easier to drive; doesn't pollute"
"Nice quiet car really a joy to drive"
"Enjoyed driving it; really fast"
"Good range"
"Liked the pep, took hills really well"
"Acceleration was outstanding"
"Changed from a skeptic to a person that will consider buying one"
"Was pleased that it satisfied all of my driving needs during the period"

Significant other positive trends related to a favorable reaction to home charging (i.e. passing up gas stations) and the fact that it was a non-polluting vehicle. These two concepts were new to most participants and they responded positively:

"Much more convenient, passed every gas station"
"Liked charging at home"
"Liked ecology of vehicle"

Additional positive trends were: Liked the unique body style (5% of comments) and that it was a lot like their own car to drive (3% of comments).

4.1.2 Negative comments The only consistent negative trend was the concern about the limited range of EVs. This trend constituted 3% of all comments but was small given that participants were not selected to accommodate

Table 2 Comments on Ecostar

Positive Comments	%	#	Negative Comments	%	#
Liked, enjoyed, amazed, etc.	16%	74	Limited range concerns	3%	14
Performance and handling	15%	67	Misc. (110V charging too slow, miles to discharge gage not all that accurate, etc.)	2%	9
Acceleration and hill climbing	13%	60	Torque related (tire spin and steering)	2%	7
Quietness	8%	37	Tire related (noise and grooves in freeways)	2%	7
Home charging (passing up gas stations)	8%	36	Needs power steering and adj. column	1%	5
Liked idea of non-polluting vehicle	7%	33	Daily charging was an inconvenience	1%	5
Liked body style	5%	25	Too quiet for pedestrians	1%	4
Misc. (perfect 2nd car, found that 100 mi. range is OK, liked preconditioning, etc.)	4%	20	Blind spots (related to body style)	1%	3
Similar to gas vehicle	3%	14	Needs more top speed for freeways	1%	3
Friends and relatives liked	3%	14	Wants audible messages and warnings in addition to instrument panel lights	0%	2
Good air conditioner	2%	10	Safety concerns with hot battery	0%	2
Good seats	1%	3	Didn't like key removal without being in Park	0%	2
Total	86%	375	Total	14%	81

the Ecostar's limited range. Thus, the few concerns over limited range could be considered as a positive indicator. Typical comments made relating to these subjects included:

"Wanted more range so that I could visit relatives in San Diego"(a one-way trip of 110 miles)

"Need charging stations in public places" (such as the Forum which was more than 50 miles away)

Two additional trends were apparent in the negative group: The high initial torque applied to the front tires (2% of comments), and certain characteristics of the high pressure tires (2% of comments). Typical comments made relating to these subjects include:

"Needs traction control"

"Tires catch ridges in freeway"

4.2 General Comments The final question of the interview allowed the participant a chance to address any issue applicable to alternate fuel vehicles that was on their mind.

Q8. Do you have some general comments about the alternative fuel vehicle industry (i.e., the big picture) that you would like to make?

Two major trends developed from the responses to this question. The first major trend indicated that the public was ready for electric vehicles based on the demonstrated performance and range capacity of the Ecostar. This category includes feedback from the demonstration rides that the participants gave their friends and neighbors. The second major trend was strong support for the development of alternate fuel vehicles by the participants. This support was based primarily on their experience with the Ecostar since only two of the participants had previous experience with alternate fuel vehicles. Two smaller issues that surfaced are whether or not the government should mandate zero emission vehicles and questions concerning oil industry interference in this market. Table 3 provides a summary of the 156 comments received in response to this question. The data shows strong support and public acceptance of alternate fuel vehicles, particularly EVs. As a group, the major issues surrounding the development of the EV market were addressed. These issues center around the limited range of an EV, the need for public charging stations, the high cost of batteries and battery replacement, and government involvement Some typical comments:

"Hope that they can come up with better batteries that are more user friendly in the future. Should be able to drive anywhere and not worry about running out of charge. Need to establish EV service stations for recharging as soon as possible."

"Was negative on EVs but this car showed me that EVs are a viable product. For EVs to succeed in market place, need high volume production, good range and infrastructure. Its refreshing to see a company like Ford develop a product like the Ecostar."

"Never considered buying an EV until I drove the Ecostar; it sold me."

"Need hybrid vehicle to overcome range restriction. Like to see vehicles that can be refueled quickly."

"Federal government needs to spend money to reduce the need for gasoline."

5.0 OWNERSHIP CONSIDERATION

The participants were asked if they would consider buying a 100 mile range vehicle and a 50 mile range vehicle. The question concerning buyers threshold for purchase price truly interrelate the two questions dealing with range. Accordingly, this data was combined to provide the most accurate result. The two related questions were:

Q2. Will you consider purchasing an electric vehicle if it has performance and range similar to the Ecostar?

TABLE 3 General comments on industry

Comment Classifications	%	#
Sees strong evidence that public in Southern Calif. is ready for EVs	38%	59
In general, supports alternate fuel vehicle industry	26%	41
Supports efforts to install public charging infrastructure	7%	11
For government mandates	6%	10
Wants to see EVs in use on streets/freeways	5%	8
Sees the limited range of alternate fuel vehicles as a problem	5%	8
Sees price and economy of alternate fuel vehicles as a problem	4%	7
Wants to see hybrid EVs developed so that range is not an issue	3%	5
Against government mandates	3%	4
Senses that oil industry doesn't want to see an EV market develop	2%	3

Q4. Assume that you can choose the desired body type such as a 4-door sedan, or pickup, in an electric vehicle that has performance similar to an Ecostar, but with only a 50 mile range. Will you consider purchasing such a vehicle?

5.1 Range vs. Buyers The data clearly indicated that range capability was the prime feature that identified buyers from non-buyers. Table 4 illustrates the stratification of buyers according to range capability of the vehicle. Some of the buyers of the 50 mile range vehicle wanted a low purchase price or to have the capability to recharge at work as a qualification to buying this type of EV. Actually 15% of the participants indicated that they would consider purchasing an EV that had a 50 mile range. For EVs that have a 100 mile range, 76% of the participants considered themselves as potential buyers. An additional 8% of participants indicated they would be buyers if the EV had a 150 mile range, and an additional 4% are buyers at ranges greater than 150 miles. The total potential buyer category includes 88% of all participants. For the 12% that felt they were not buyers, the reasons given center around the fact that they want gas vehicle range and quick refueling. Also, some participants only own one car and an EV would be too limiting for them. Comments that typify responses applicable to the 50 mile range vehicle are:

"Yes, I am willing to buy if I can charge it at work"
"Yes, it fits my needs"
"No, not willing to buy a 50 mile range vehicle because I would always be concerned about taking longer trips"

Comments that typify responses applicable to the 100 mile range vehicle are:

"Yes, it will have to be a little larger, but I can't wait until it is available"
"Yes, but I need a 150 mile range"
"Yes, absolutely"
"Yes, I like new technology, it doesn't pollute and it fits in with our lifestyle"

5.2 Buyers Justifications The majority of participants (81%) used comparable gasoline vehicle prices to justify the price for buying an EV. A significant number (approximately 20% in all) indicated that they would be willing to pay more for an EV than an equivalent gasoline vehicle. As shown in Figure 4, this included 12% who were impressed and liked the Ecostar enough to pay more, the 3% who wanted a deluxe and/or high technology vehicle, and 3% who would pay more for environmental reasons. This and other data from the surveys indicate the decision to purchase the EV may be over-stated. The item about purchase intentions is questionable , although the trial results show that the Ecostar was well received, and met most daily household travel needs. Some of the other attitudinal data obtained suggest that under high involvement, showroom like conditions, respondents might not select a vehicle that had a higher cost and more limited range. It was also seen that environmental benefits did not emerge as a single independent factor and environmental opinions were weakly related to purchase intention.

Typical comments include:

"Willing to pay 18K which is what we paid for our new Camry, but we would be willing to pay as high as 25K to get the convenience"
"Having just bought a new car in the low twenties; somewhere in the range of 20 to 25 K"
"'Willing to buy an EV because it is exciting and a way that we can contribute to the environment"
"The price depends upon the body style, creature comforts, features, and two seater versus a four seater and so on. Ecology justifies purchase"

Table 4 Desired range versus buyers

Buyer Responses	Question 2: (50 miles)	Question 4: (100 miles)	Accumulated Buyers
Yes, 50 mile range is OK if it has a low price	3		4%
Yes, 50 mile range is OK if I can charge at work	4		9%
Yes, 50 mile range is OK (includes all conditions)	11		15%
Yes, 100 mile range is OK		57	76%
Yes, if it has a 150 mile range		6	84%
Yes, if it has more than a 150 mile range		3	88%
Non-Buyers			
No, 50 mile range is too limited	57		76%
No, not a buyer of an EV		9	12%
Totals	75	75	

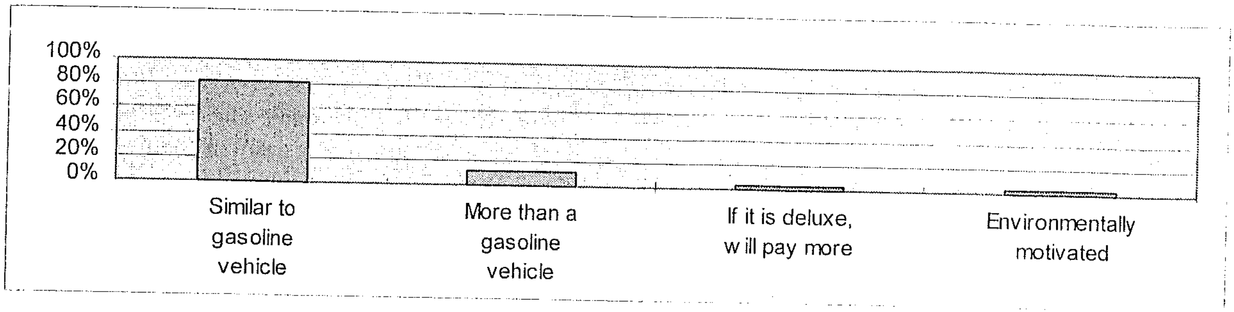

Figure 4 Buyers purchase indications

6.0 RETAIL CONSUMER CONCLUSIONS

6.1 Overall

- A competitively priced (relative to a comparably priced gasoline vehicle) EV with 100 miles range (requires an advanced battery) and Ecostar like performance could be marketed successfully as an urban commuter vehicle to multiple vehicle households.
- Wide availability of work site charging and public quick charging would rapidly expand the EV urban commuter market.
- An EV with 50 miles range, however, could not be marketed successfully without a major price reduction versus a comparable gasoline powered vehicle.
- There was wide support for the commercialization of the EV industry and strong indications that the general public is ready for EVs.

6.2 Range and Conductive Charging

- People adapted easily to the 100 mile range of the Ecostar, and for the majority of day-to-day driving this range was satisfactory.
- The mean daily mileage difference between the gasoline vehicles and the Ecostars was approximately 12%; however, the Ecostars were seldom driven to a maximum discharged condition. The differences in trip distance was most noticeable for social and recreational trips especially those taken by the older participants.
- After having the experience of using the EV, participants said they were more likely to switch the longer trips to other household vehicles, and less likely to depend upon public recharging opportunities to make the trip in an EV.
- During the trials, overnight charging at home was the primary option. With actual experience, drivers expressed the most interest in being able to recharge at work, shopping centers, and recreation centers.
- Participants had a very favorable reaction to home charging using low cost conductive charging equipment (standard equipment with the Ecostar), and liked the idea of avoiding the gasoline station.

6.3 Performance

- The majority of people liked the Ecostar because of its performance, handling, and quiet operation.
- People enjoyed driving the Ecostar and especially liked the immediate acceleration from the stopped position.
- The fact that an EV is a non-polluting vehicle was very appealing to people.
- Once people had the opportunity to drive the Ecostar, approximately 88% were convinced that it was a marketable product and were interested in buying an EV with this level of performance.

6.4 Purchase Considerations

- Once they had experience with the Ecostar, approximately 76% of the population would consider purchasing an EV with a 100 mile range. Approximately 80% of this segment wanted the purchase price comparable to an equivalent gasoline powered car.
- For an EV that had a 100 mile range, approximately 20% of the population indicated they were willing to pay more than for a comparable gasoline powered car. The prime motivation for this purchase was the prestige of owning a new technology product and/or satisfying their environmental concerns.
- Once they had experience with the Ecostar, approximately 24% of the population said that they would consider purchasing an EV with a 50 mile range; however, many in this segment needed the capability to charge at work and/or wanted a lower purchase price.

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[1] Brodt, D. and Dot, M. (1995) SCE Conversion and Preproduction Electric Vehicle Trials Program (March 1993 - December 1994)

[2] Golob, T. F., Stwertnik, K., and Torous J. G. (1996). Uses of Gasoline versus Battery Electric Vehicles: An Analysis of Travel Diaries from the Ford Ecostar Customer Evaluation Program in Southern California

Infrastructure for EVs - State of the Art and Promotion Policies in Germany

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ABSTRACT: Next to the availability of EVs and the home charging possibilities for them it is necessary to create an infrastructure of opportunity charging stations for a wide introduction of EVs. In Germany there have been exactly 100 stations in January 1996. This report tells about the specific conditions of these stations, their use by EV drivers including difficulties which have come up since their installation. In Germany no specific legal regulations have been proposed to introduce charging stations for EVs, but there are legal conditions given by other laws which could support the introduction. Infrastructure systems have also been tested in the field test on the island of Rügen and test programs in resort areas in southern Germany and will be tested in the Zinc-Air battery project of the German Post. A basic political support is still missing in Germany allthough the industry is engaged in the development of EVs and the infrastructure.

1. INTRODUCTION

The interest for the introduction of EVs is growing but next to the shortage of reliable batteries and the necessary change of the behaviour pattern of drivers towards driving an EV it is important to have a suitable infrastructure for charging the batteries. The home charging facilities are usually sufficient and have been used to an extent of more than 90% in the latest field tests of Rügen in Germany and La Rochelle in France, but it is necessary for the well-feeling of the drivers to have the possibility of opportunity charging although it seems not to be necessary according to the actually driven range. From statistics and experiences it is known that the average mileage driven in German cities is about 45 to 50 km, but normal drivers have the feeling that they at least must be able to drive 100 km. Therefore opportunity charging stations have to be designed and installed taking into account previous experiences. Differences will be made between

- rapid charging stations
- opportunity charging stations on public ground,
- opportunity charging stations on private round,

in this report.

2. STRUCTURE OF OPPORTUNITY CHARGING STATIONS IN GERMANY

There were exactly 100 opportunity charging stations in Germany as counted at the beginning of 1996 installed by city governments, companies and private persons. These have been asked in a questionaire about the structures and experiences with their stations. The answers from 66 questionaires being sent back have been put into the following statistical form.

Fig.1 gives an impression of the time period of their installation. It shows that during the high time of public support of EVs in 1992 and 1993 the highest numbers of stations have been installed by utilities (40%), private companies and persons inclusive associations (39%), communal agencies (10%) and others like department stores (11%). Often (> 50%) the support came from programs for the installation of solar energy panels.

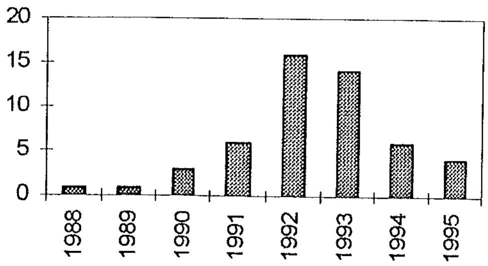

Fig. 1: Installed opportunity charging stations during the last 8 years

These stations have been installed on private and public ground according to Fig.2. 9% were undefined. The plugs used are safety plugs normally used in Germany, in some cases in addition CEKON plugs (230 and 400 V) as they are used on camping grounds in Europe. The maximum current is 16A.

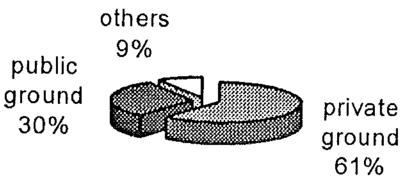

Fig. 2: Locations of opportunity charging stations

There is a great variety of charging stations since the set-up is not yet fixed by state or other regulations except the regulations for handling with electric devices. More than 10 companies offer their products on the market. As an example Fig. 3 shows the "Stromtankstelle" from the AEG, which can be mounted to a wall or on top of 2 steel tubes.

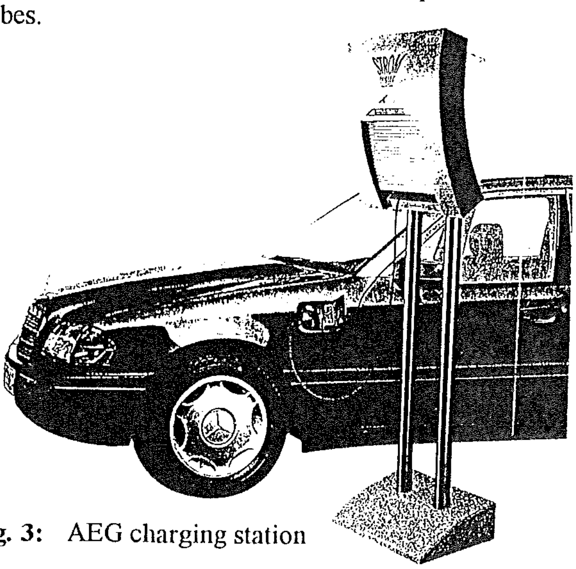

Fig. 3: AEG charging station

The number of parking lots per charging station is listed up in Fig. 4.

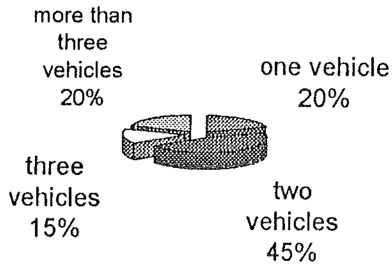

Fig. 4: Number of parking lots per charging station

There are 4 types of payment systems:
- no fees for parking and energy
- fees for parking with energy fees included
- free parking, fees for the energy
- extra fees for parking and energy

The last possibility seems to have been abandoned since in an earlier questionaire there had been 7 out of 101 charging stations. Fig.5 shows the distribution. Free parking and free energy is mainly offered by the utilities. As a result it can be said that a parking meter without counting the energy (an energy metering device is too expensive compared to the energy cost paid by EV driver) would be the best, at least during the introduction period.

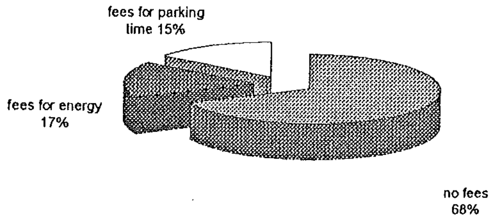

Fig. 5: Payment systems of opportunity charging stations

3. EXPERIENCES WITH THE USE OF OPPORTUNITY CHARGING STATIONS

The installation of opportunity charging stations caused no major technical problems since the technology to be used is well known. There were only some problems due to administrative procedures. There is no definition up to now what kind of object is a charging station:

Is it an electrical object like a street lamp or an electric distribution cabinet, a parking meter or an object like an advertising pillar or something new still to be defined? The approval for installation needs time, since usually the approving agency has no experiences. But also technical problems arise since there are many kinds of charging stations, often home made ones. The manufacturing of charging stations has not yet come into the state of an always reliable series production. Fig.6 shows the distribution.

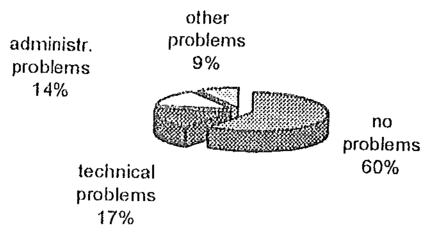

Fig. 6: Problems during the installation of opportunity charging stations

The operation of the stations seems to be quite successful as Fig.7 is demonstrating.

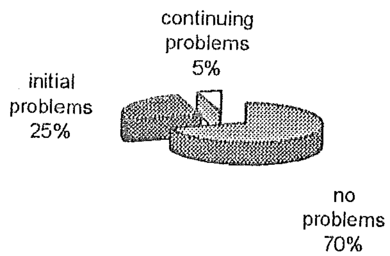

Fig. 7: Problems during the operation of opportunity charging stations

The frequency of the use of these stations is not yet satisfactory as Fig.8 is showing. Some stations are used only sometimes per month. This is influenced by the fact that there are only 4700 EVs in Germany and some stations are not located at places convenient for drivers to do their business.

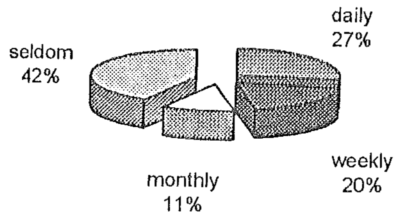

Fig. 8: Frequency of the use of opportunity charging stations

In Germany there is often the discussion about the necessary procedure if the charging station is blocked by conventional cars. The statistics say that only 12% have been confronted with this problem, but at least 25% are located to the stations on public ground. Therefore legal means have to be taken to handle this problem.

4. LEGAL REQUIREMENTS FOR THE INSTALLATION OF OPPORTUNITY CHARGING STATIONS

There has been a wide discussion on a possible support of the introduction of EVs in Germany by laws like the California Clean Air Act. At this moment there is no chance to pass a law like that through the German parliament. It is said that an existing law about the limits of emissions caused by the traffic gives enough possibilities for a city government to close city centers and to allow emissionfree vehicles to drive there. In a few resort areas in southern Germany this has been done, but the majority of city mayors are still hesitating to do so - they fear not to be reelected.

A special law for parking lots for EVs is also not reachable - some other pressure groups also want a special allowance for parking. Even if a sign is put up which says "only for EVs" the police has no power to take a conventional car away. In Switzerland a park & charge system has been created which allows the police to collect parking penalties.

The installation of mechanical barriers which can only be overcome by EV drivers is also under discussion, but it seems it cannot be applied in all cases.

5. CHARGING STATIONS USED IN FIELD TESTS WITH EVs

The Federal Ministry of Education, Science, Research and Technology (BMBF) had launched the big 4 years demonstration-project "Testing the latest generation of EVs on the Rügen Island" in northern Germany which was finished on Dec. 31, 1995. The main idea was to test modern drive and battery systems in 60 EVs under everyday conditions, to test the infrastructure systems and the acceptance by the customers as well as finding out the impact on the environment. The car manufacturers BMW, Mercedes Benz, Neoplan, Opel and Volkswagen as well as the battery manufacturers DAUG, VARTA, ABB, and AEG Anglo Batteries and the local utility had been involved. All EVs travelled more than 1.1 mio. km.

In this field test a few normal (230 V, 16 A) charging stations and one rapid charging station (30 kW) had been installed. The final report about the test has not yet been published. It will be available in October 1996.

The field test of the Deutsche Post AG with 64 EVs is just in the process of starting. The zinc-air-batteries are charged mechanically - i.e. by exchanging and regenerating the zinc-anode. A regeneration station has been built up in Bremen in northern Germany.

The test will last 2 years and will have the goal of testing economical aspects of EVs in fleet application. After that time statistics will be available.

In southern Germany there is a field test with about 10 electric buses of the companies NEOPLAN and LARAG in 4 resort areas under the headline of "Car-free resorts and touristic areas in Bavaria" which has been proclaimed by 21 communities. NEOPLAN has invented a special charging station which allows the automatic change of batteries in 5 minutes. Fig. 9 gives an impression of this station.

6. ENERGY SUPPLY FOR EVs

A report on "EVs and mobility" published 3 years ago revealed that there could be the replacement of more than 5 mio cars of altogether 40 mio cars in Germany by EVs since their daily driving range is less than 100 km. In detail this report stated that the use potential is

- 5% of the passenger cars in 1-car households, i.e. 5% of 55,5% of all cars,
- 40% of the passenger cars in 2-car households, i.e. 40% of 35,6% of all cars,
- 55% of the passenger cars in households with 3 and more cars, i.e.55% of 8,9% of all cars.

The market potential is of course much lower and dependent of the price of an EV which is still higher than that of a car with a combustion engine.

The infrastructure of electric energy sources is sufficient in Germany. If there would be 1 mio. EVs and they drive about 45 km during a day - this is the statistical mean value - the energy consumed for this distance would just be 1% of the total consumption of electric energy. Hence, no new power stations are necessary, even if all EVs would be charged during the day. During the night there are also no problems - even not for 5 mio.EVs. The rapid charging will also cause no problems since it is used very seldom, as experiences in Rügen and La Rochelle prove. They only give a feeling of safety in emergency situations. People will be planning their trips and the charging in future according to their driving habits.

7. NECESSARY POLITICAL SUPPORT

As has been shown above there are no real problems in creating an infrastructure for charging up EVs. The market is ready to start a production of charging stations but the number of EVs (about 4700 in 1995) is growing too slowly. The political support is very small. The ministries in the German government do not have a common opinion about the introduction of EVs - so no initiative is coming at this time from the political side. But this is necessary to break up the vicious circle

"no support
→ little industrial initiative
→ no series production
→ too high prices
→ too small market
→ no effect on the improvement of the environment
→ no reason for a state support"
in order to create better living conditions

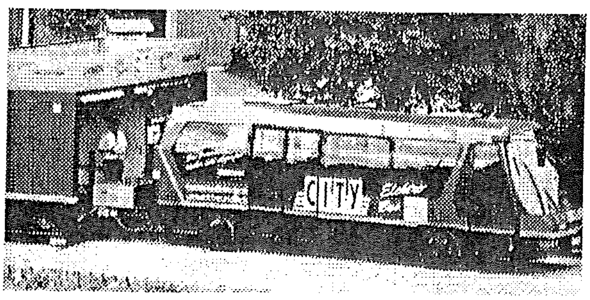

Fig. 9: A NEOPLAN midibus changing its battery set at a specially developed battery charging container

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EUROPEAN ACTIVITIES ON STANDARDIZATION FOR ELECTRICALLY PROPELLED ROAD VEHICLES AND RELATED LEGISLATIVE REQUIREMENTS

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ABSTRACT :

The technical committee 301 of CEN in coordination with ISO is progressing in setting up standards for electric and hybrid vehicles dedicated to operational and energy performance, as well as to safety aspects.

The topics covered by the standards are procedures for measurement of road operational and energy performance, charging related aspects and safety provisions concerning electric system, batteries and functional behaviour.
Scope of the standards is also to contribute to the definition of legislative documents for electric vehicles type approval, some of which have been already implemented.
A work partition is being defined between ISO and IEC, to cover, in harmonized way, also the topics more related to electrical components and the aspects concerning the recharging situation, with the vehicle connected to the mains

1. INTRODUCTION

As a supportive action to the starting of electric vehicles commercialization, since 1992 the Technical Committee 301 of the European Committee for Standardization (CEN) has undertaken an activity to define rules and procedures for the EV characterization and for the establishment of the appropriate level of safety.
The work is harmonized with the standardization activity which is being performed at the worldwide level by ISO on the same thematic areas.
The standards which are object of activities of CEN and ISO are dedicated to the aspects of the vehicle characterized by the electric traction system, in terms of performance and safety issues, which, on the other hands are aspects considered at the level of vehicle type approval, to certify its features in relation with the practical use.
Actually, some provisions of standards developed by CEN-ISO have been taken as a basis for establishing the regulations within UN-ECE for electric vehicles. The standardization activity on electrically propelled vehicles is complemented by that concerning items more related to electrical components and the interactions between vehicle and mains. These items are developed by IEC TC 69 at the international level and by CENELEC TC69X at the european level, according to a work partition being defined between ISO and IEC.

This paper describes the content of the standards developed and under development by CEN/TC 301 especially concening the recent achievements; previous activities CEN/TC 301 [1] are recalled and summarized.

2. APPLICATION AREAS

A background of the standardization which has been established is a clear understanding of the terms of reference and of the finalization framework which the standards are addressing to.

2.1 Terminology

The definition of terms has been performed for components, subsystems, vehicle type, energy supply and driving mode.
Some examples are here reported.

- **on board energy source** : is a system which delivers energy (electric or other) for traction purpose. It includes an on board energy storage, an energy delivery system and any ancillary devices. The energy storage can be fed from the outside of the vehicle
- **on board primary electric energy source :** is a system which stores energy and delivers electric energy in an unreversible process.
  Examples :
  a) Fuel cell (Input is solid or fluid fuel + gas (oxigen or air) and Output is electric power + associated reaction elements)
  b) Generating set (Input is fuel in a tank + thermal machine (combustion engine, gas turbine + electric generator(s) and Output is electric power)
- **on board secondary electric energy source :** is a reversible system which stores electric energy(under chemical/mechanical/electro-static form). Input and Output are both electric energy. Examples :
  electrochemical storage battery, capacitor, fly/wheel/motor-generator unit, etc. and any combination of the above components.
- **Electrically supplied vehicle**
  is a vehicle which is supplied by electricity as an external enregy source for traction purpose. It comprises two families :
  First family : infrastructure indipendent or autonomous when driving : this vehicle shall have an on board electric energy storage for traction purpose which is recharged periodically.
  Second family : infrastructure dipendent when driving. This vehicle is continuosly electrically supplied when driving.
- **Pure electric vehicle**
  is an electrically propelled and infrastructure indipendent exclusively electrically supplied road vehicle.
- **Electric hybrid vehicle**
  is an electrically propelled road vehicle integrating an electric traction system which permits a pure electric driving mode and having at least one additional other kind of on board energy source for propulsion.
- **Thermal electric hybrid vehicle**
  is an electric hybrid vehicle in which the "non electric" energy storage is such to feed a thermal engine (i.e. IC engine, gas engine, etc.).
- **Pure electric driving mode for an electric hybrid vehicle**
  is the driving mode when only the secondary on board electric energy source is allowed to participate to the propulsion of the vehicle.
- **Hybrid mode for an electric hybrid vehicle**
  is any other driving mode than the pure electric driving mode. All the on board energy source storages are available to participate to the propulsion of the vehicle, according to the management system logic.

2.2 Thematics

The standards concern the following items :

ROAD PERFORMANCE

- Measurement of road operating ability of :
  - Pure electric vehicles
  - Thermal electric hybrid vehicles
  - Other hybrid vehicles than those fitted with a thermal machine
- Measurement of energy performances of :
  - Pure electric vehicles
  - Thermal electric hybrid vehicles
  - Other hybrid vehicles than those fitted with a thermal machine
- Measurement of emission of :
  - Thermal electric hybrid vehicles
  - Other hybrid vehicles than those fitted with a thermal machine

BRAKING OF ELECTRIC VEHICLES

CHARGING RELATED ASPECTS

- Airborne acoustical noise
- Ventilation of garages
- Charging connection

SPECIFIC PRESCRIPTIONS FOR SAFETY

- On board energy storage
- Functional safety means and protection against failures
- Protection of users against electrical hazards

3. ROAD PERFORMANCE

3.1 Basic Concepts

The introduction of the electric vehicle on the market requires a new kind of communication among car manufacturers, customers and

authorities. The CEN/TC 301, composed of experts from the European Countries, often assisted by national working groups, proposes the basic characteristics, the performance procedures to take into consideration, and their measurement in order to describe or compare the various electrically propelled road vehicles.
The main purpose is to get realistic measurements, as close as possible to the daily conditions of use encountered by the customers.
In particular, the effects on the electrically propelled vehicle performance of battery state of charge and payload have been taken into account, keeping in mind that they must be able to follow the traffic without causing any disturbance. Additionally, the results ought to be as far as possible comparable with those of similar conventional cars.
A second important purpose concerns the means needed for performing the tests, to save time and investments. So, all testing conditions have been defined, as well testing facilities, measuring equipments, and the measuring process.
The main testing conditions defined are :

- material environments : climate (outdoor, indoor), tracks (e.g. loop, slopes), and benches calibration (e.g. chassis dynamometer)
- vehicle conditionning : initial : standard fittings (e.g. charger, conventional equipments), preparation, for each day or test sequence (preconditionning, initial deepth of discharge), and for each tests (mass required).

The measuring process defines test sequences where the tests follow on from each other in a logical order in respect with the technical stresses, allowing a limited test campaign duration.

3.2 Standards for pure electric vehicles

3.2.1 Road operating ability - pr EN 1821-1, part 1 : pure electric vehicles (approved)

The performance considered by this standard are the following (underlined when presenting a new concept in respect with conventional vehicles)

- maximum thirty minute speed,
- maximum speed,
- acceleration 0 to 50 km/h,
- acceleration 50 to 80 km/h,
- speed uphill on a 4% slope,
- speed uphill on a 12% slope,
- hill starting ability

The testing conditions have been established considering the following technical stresses :

- loss of performance during discharge
- temperature limitations, from battery, motor or power electronics
- response time of drive train before accelerating

Consequences on this European Standard are:

- the most critical performances regarding traffic requirements are tested in the most unfavourable conditions; this concerns mainly the hill climbing tests, that are performed with a rather low state of charge
- creation of the "thirty minutes speed" concept, so that the electrically propelled vehicle ability to maintain a reasonable "speed during an appreciable" time will be measured. This principle has been adopted by regulation.

The test sequence appears in Table 1.

3.2.2 Energy performance-draft "prEN1986-1", part 1: pure electric vehicles (sent for final approval)

The need of comparison with conventional cars led to adopt an existing reference test cycle; the cycle "frame" defined by the Directive EEC 91/441, already used for conventional cars, but with some adaption, as below described.

Consumption measurement :

The main adaption is a choice offered between two test sequences.
This decision was made considering that EVs car show better results in urban or extra-urban test depending on their design, and that some future regulations could prefer the one or the other one, depending on the country considered.
The reference test cycle is :

- either the complete cycle now called MVEG or 150A, a series of four "basic" Urban Driving Cycles (UDC), followed by one Extra-Urban Driving Cycle (EUDC), that complete cycle being applied two times (~22 km)
- or only the (fourfold) urban part UDC, but to be applied seven times (~28 km)

Concerning the EUDC, the high accelerations required exceeding the potential of most EVs (and also the effective needs), their tolerances have been adapted : like in UDC, they stay required up-to 50 km/h, with respect to urban traffic fluidity; but at higher speed, what is required is only that the accelerator pedal should be maintened fully depressed.

Range measurement:

The reference test cycle is the complete MVEG/150A = 4*UDCs + 1*EUDC, to be performed from fully charged battery to the end-of-test criterion. This is reached when the EV is no more able to respect, the cycle tolerances under 50 km/h, and the effective range (which can be rather lower than the theoretical distance corresponding to the number of cycles performed) is recorded as the result of the measurement. The sequence of tests is shown in Table 2.

3.3 Standards For Thermal Electric Hybrid Vehicles

3.3.1 *Road operating ability* - draft prEN1821-2-part 2 : Thermal electric hybrid vehicles
This standard defines conditions and procedures to measure the road performance in hybrid mode and in pure electric mode:

a) Hybrid mode (*)
- maximum thirty minute speed
- maximum continuous speed
- maximum speed
- acceleration 0-50
- acceleration 0-100
- acceleration 50-80
- acceleration 80-120
- speed uphill
- hill starting ability

(*)If several driving modes are available - including a pure thermal mode - the one to give the best measured performance (for each single feature) can be selected.

b) Pure electric mode
- maximum speed
- acceleration 0-50
- acceleration 50-80
- speed uphill
- hill starting ability

The established sequence is shown in Table 3.

3.3.2 *Energy performance and emissions* : - draft prEN1986-2, part 2 : Thermal electric hybrid vehicles (under development)

The thermal electric hybrid vehicle can be operated according to pure electric or hybrid mode.
A pure thermal mode is also in principle conceivable, but in this case the vehicle behaves as a conventional vehicle and the relevant rules and procedures are applicable.
The measurement of energy consumption and range in pure electric mode is performed according to the same procedures as for pure electric vehicles (pr EN1986-1).
The energy consumption in hybrid mode is intended to be composed by the consumption of the electricity drawn from the mains and the conusmption of fuel.
As reference cycle for energy consumption the same cycle considered for pure electric vehicles (pr EN 1986-1).
Due to the possible variety of thermal hybrid vehicles and related system management strategies, it is prescribed that the total distance covered during the test should exceed the range in pure electric mode, in order to assure that at least one cold start of the thermal engine will occur.

The values measured during the test are :
- the total distance d
- the electric energy from the network E
- mass of carbon dioxide
- mass of carbon monoxide
- mass of hydrocarbons
- mass of nitrogen oxide
- mass of particulates (for compression ignition engine only)

The electric consumption EC is then calculated by the formula

$$EC = E/d \text{(in Wh/km)}$$

The fuel consumption FC is calculated from hydrocarbon, carbon monoxide, and carbon dioxide emissions, according to lasts amendment of Directive EU 93/116.
The total consumption of the vehicle is defined as follows :

$$C = EC\text{(Wh/km) and } FC \text{ (l/100 km)}$$

4. CHARGING ASPECTS

Concerning the charging of EVs there are three main topics to consider at present.

4.1 Airborne Acoustical Noise

Contrary to I.C.E. powered vehicles, EVs can produce noise over a longer period of time, when the battery is charged.
Different airborne noise limits exists in various European Countries or even no legislation noise limits exist in some of them (see Table 4).

Taking into account this situation rather than establishing a noise limit for electric vehicles at charging as a standard, it is important to standardize the method of measuring. This is being presently defined on the basis of various ISO standards already existing on the matter of acoustics.

4.2 Ventilation of Garages

When a battery (other than a sealed battery) is charged in a closed area, ventilation is necessary, to avoid the formation of critical hydrogen concentrations. A standard is necessary to specify the ventilation requirements of closed areas (garages) used for this purpose. Ventilation levels have to be specified such that the maximum hydrogen concentration in the air is limited to 4%.

4.3 Charging connection

The charging process itself needs standardisation. The power connection between the vehicle and the cord

to the grid or to an external charger shall be standardised, furthermore the communication between the vehicle and an external charger needs standards regarding the relevant protocols.
All these topics are presently considered in the different standardisation organisations.

5. SAFETY RELATED PROVISIONS

Three projects of standards have been prepared the first two have been approved and have been assumed as basis for regulation proposals.
The third one is under elaboration.

5.1 Part 1 : On board energy storage

The standard aims to defining all requirements specific to the electrically propelled vehicles in order to assure safety both for the user of the vehicle and for the environment of the vehicle (pedestrian, nature protection against pollution, etc.).
The following aspects are considered, for which specific prescriptions are given :

- Exhaust gas from battery driving charge : the vehicle manufacturer shall state the maximum output of potentially dangerous gases in case of normal service and in case of a first failure of devices involved in the charging process. These values shall determine the ventilation device if any, in the charging room, in accordance with the specific standard.

- Installation rules of the battery :the following items are dealt with and related prescriptions are given.
  - = Insulation resistance of the battery to the chassis; required minimum 500 Ω/V for new battery and 100 Ω/V within its life
  - = Creapage distance
  - = Ventilation
    Prescriptions when gases may be produced by the battery
  - = Overcurrent battery switch, having the function of opening the battery current circuit in case of failure in the drive system or of short-circuit of the battery .
  - = Specific requirements for the crash test (e.g. the battery shall not penetrate inside the passenger compartment or in any case its movement shall be limited to ensure the safety of the passengers and shall not be ejected from the vehicle).

5.2 Part 2 : Functional safety means and protection against failures

The principal provisions prescribed by the standards are the following :

- Operational safety: the provision concern
  - = The system power-on procedure (to prevent non-voluntary manouvers).
  - = The indication to the driver of reduced power (e.g. consequence of low state of charge of battery, high temperature of the drive system)
  - = The indication of low state of charge of the traction battery
  - = The avoidance of the possibility of unintentional driving backwards
  - = Acoustical or optical signal during parking if the system is still in the mode "active driving possible".
  - = A master switch to allow disconnection at least of one pole of the electric power source from the drive system at any time.

- Protection against failures: the principal provisions concern :

  - = Unintentional vehicle behaviour shall be prevented. A failure shall not cause more than 0,1 m movement of a standing vehicle
  - = Any unexpected disconnection of electrical connectors shall not lead to hazardous behaviour of the vehicle.

5.3 Part 3 : Protection of users against electrical hazards

Scope of this standard (which is still under elaboration) is to define the requirements for electrical safety, when the vehicle is not connected to the external power supply.

In order to established adequate safety levels for the various categories of electric vehicles, voltage classed categories have been established, also taking into account IEC standards :
The principal provisions concern :
- Protection against direct (contacts with liveparts of electrical circuit)
  - . For circuits of voltage class A (0-30 V d.c.) no protection is required and one circuit pole can be connected with the vehicle chassis.
  - . For circuits of voltage class B (0-30 V d.c.) and C (60-1500, the protection shall be ensured either by insulation or by barriers or enclosures.
    Detailed requirements are given.
- Protection against indirect contacts that are possible contacts with exposed conductive parts in case of failures of electrical circuits.
  - . For voltage class A and B no specific protection is required
  - . For voltage class C, the protection can be obtained either by potential equalization of the exposed conductive if the circuit insulation is in Class I or by use of Class II

electrical equipment , with a double or reinforced insulation.

- Protection against water effect, that can occur during washing of the electric vehicle. After test simulating a washing operation, according to EN 60529, or after a wading test, the vehicle shall comply with the insulation resistance test.

6. HARMONIZATION CEN/ISO ON EV STANDARDS

Within the parallel development of standards for EVs made by CEN (mainly in view of regulations for type approval) and by ISO (for getting standards at international level) considerable efforts have been made to avoid duplication of work and moreover to assure a common understanding. These actions resulted in almost identical papers for EVs on "Road operating ability" (pr EN 1821-1 and ISO/DIS 8715) and on "Energy performance" (preEN 1986-1 and ISO/DIS 8714-1). Harmonization activity is continuing also on standards concerning safety issues (pr EN 1987-1, 2, 3 and ISO/DIS 6469.3).

7. REGULATIONS FOR ELECTRIC VEHICLES

Prescription for the type approval of road vehicles, other than national ones, are the directives of the European Union (EU) and the regulations of the United Nation's Economic Commission for Europe (ECE). The regulations are, despite the word "Europe", more global, as e.g. US and Japan are contributing and as they may be applied worldwide. On most issues, the precriptions are harmonized, after their definition in one of these organisations.

Regarding the EVs, the prescription are being developed by the expert's-groups of Working Party (WP) 29 of the ECE since 1994 and presumably they will be adopted by the EU.

In most cases, this work has been done by amending existing Regulations (R....) for Road vehicles with internal combustion engines so that they are becoming applicable also to EVs. This could be reached by slight amendments or by adding chapters or annexes, containing the different procedures for EVs.

Table 5 shows the updated situation for EVs been defined on the basis of the standards elaborated by CEN and harmonized with ISO.

8. COORDINATION ISO-IEC

ISO TC22/SC21 and IEC TC 69 are working since long time on electric vehicle standardization regarding especially aspects tied to vehicle features and electrical equipment respectively.

The intensification of the activities, the technology development, the necessity of common understanding also in relation to international relations in the field of electric road vehicles, has required the definition of a clear work partition for standard development; this in order to avoid duplication of work, to make profit of the matter related experties, to cover in a rational way all the spectrum of issues concerning EVs and to serve a guideline for the activities performed by the Continental or County standardization bodies. ISO and IEC are presently defining this work partition which in principle will be consistent with the following concepts :

◊ The electric vehicle as a whole should be dealt with by ISO

◊ The electric components and the aspects related to interconnection with the electrical infrastructure should be matter of IEC.

9. CONCLUSIONS

The start of commercialization of electric vehicles has required the availability of a framework of standards beyond the national context of the different countries, as well as the definition of regulations for type approval.

CEN activity, harmonized with ISO, has defined basic standards for electric vehicle characterization in terms of road operating ability, energy features and safety, which have served also as a basis for regulations definition.

The work is continuing also concerning standards for electric hybrid vehicles.

The standards are conceived in such a way to assure a common understanding of the various issues, to address all the fundamental aspects for vehicle performance and safety and, in coordination with IEC/CENELEC to cover the interaction vehicle-infrastructure.

The standards are structured in order not to hinder the evolution of the technologies, but to leave freedom to a variety of technical solutions, in the frame of common methodologies for vehicle characterization and provisions for safety.

We consider that this activity on standardization shows a general interest on electric vehicles and is a mean for contributing to their development.

10. REFERENCE

[1] C. Peyriere, E. Combes, Y. Martinod, G. Brusaglino, K. Orchowski, B. Sporckmann, J. Hilaire - "Standardization activity for the electrically propelled road vehicles" - Proceedings of EVT95, Paris, november 1995.

Table 1 - Test sequence for road operating ability of pure EVs

	PRECONDIT./TESTS	MEANS/FACILITIES	DETAILS/PROCEDURES
First day	Preconditioning:		
	normal charge	indoor plug	excludes equalizat.
	warm up		-5km@80% of V30
	Max, 30' speed(V30)	loop track or dynam.	30'@claimed V30
	Complete battery disch.	"	@70% of V30
Second day First sequence	Preconditioning	same as 1st day	same as 1st day
	Max speed	loop or straight track	1 km in both direct.
	Reach 40% battery discharge	loop track or dynamometer	from starting of 2nd day, 40% of 1st day covered distance
Second sequence	Accel. 0 to 50km/h	loop or straight track	in both directions
	Accel. 50 to 80km/h	"	"
	Max,speed uphill on 4%	chassis dynamometer	1 km@stable speed
	Max,speed uphill on 12%	"	"
	Hill starting ability	slope=claimed max.slope	>10 meters with compens. mass calcul.

Table 3 - Sequence for Road Operating Ability measurement of Thermal Electric Hybrid Vehicle

Days		Activity (A) /Test (T)	Mode
Previous night	A	Charge	
1st day	A	Warm up	Hybrid
	T	Maximum speed	Hybrid
	T	Maximum speed	Pure electric
	T	Acceleration 0-50	Hybrid
	T	Acceleration 0-100	Hybrid
	T	Acceleration 50-80	Hybrid
	T	Acceleration 80-120	Hybrid
	T	Acceleration 0-50	Pure electric
	T	Acceleration 50-80	Pure electric
	A	Complete discharge	Pure electric
	T	Max. continuous speed	Hybrid
Next night	A	Charge	
2nd day	T	Warm up	Hybrid
	T	Max. thirty minute speed	Hybrid
	T	Speed uphill	Pure electric
	T	Speed uphill	Hybrid
	T	Hill starting ability	Pure electric
	T	Hill starting ability	Hybrid

Table 4 : Noise limits or noise limit recommendations in dB(A) for different countries and zones

	Zone I		Zone II		Zone III		Zone IV	
	day	night	day	night	day	night	day	night
France	45	35	50	40	60	50	70	60
Germany	45	35(30)[1]	50	35	60	45	70	70
Italy	50	40	55	45	60	50	70	70
UK[2]	-	-	-	-	-	-	-	-
	Hospitals, Schools, Public Parks		Resident.areas		Mixed areas		Industrial areas	

1. Recommemded for hospitals only
2)Subject to local authority opinion

Table 2 - Sequences for testing energy consumption and range of pure Evs

	Preconditionning/tests	Means/facilities	Details/procedures
First day:	initial battery charge :		
	- initial discharge	loop track or dyna.	@70% of V30cf
	- normal charge	indoor plug chassis dynamometer	cf prEN 1821-1
	Energy consumption : 7*(4*UDC)		each UDC =4 basic urban cycles record distance (~28 km)
	or		or
	2(4*UDC+1*EUDC)		record distance (~22km)
	- normal charge	indoor plug	record mains consumption
Second day:	initial battery charge		cf 1st sequence or just normal charge if follows 1st sequence
	Range : complete cycles up to end-of discharge criteron	loop track or dyna.	each cycle=4*UDC+1*EUDC record range

Table5 - Regulation for electric vehicle

ECE/WP 29 Exp.group Regulation	**Subject**	**Contents Status (mid. Jul. 96)**
GRB R51 amended	Noise (Mot. veh. ≥ 4 wheels)	- specifies speed to measure noise of EV Adopted by WP29
GRPE R68, amended	Pollution, Energy Maximum speed (EV cat. * MI, NI)	- added "max 30 min. speed" for EV - added conditions to measure max and max 30 min speed for EV Adopted by WP 29
R85 amended	Net power (M, N)	- added "max 30 min. speed" for EV - added conditions to measure net and max 30 min power for E Adopted by WP 29
R..... (replaces R84) amended	Emission of carbon dioxide and fuel consumption (pass. cars) and elec. energy consumpt. and range (M1, N1 EV)	- added "electrical energy consumption and range" for EV - added conditions to measure these properties for EV Adopted by WP29
R(100) (specific for EV) new	Construction and functional safety of (battery) EV (M,N)	Prescription, concerning - hazardous gases from the battery - electric shocks - functional safety Adopted by WP29
GRRF R13 amended	Brakes, running gear Braking (M,N,O)	added prescription for electric and regenerative braking
GRSP R12	Passive safety Driver, steering mechanism, impact (M1, N1)	limits leakage of liquid electrolytc after crash test Adopted by WP29

*Vehicle categories, as defined in ECE/Trans/SCI/WP29/78/Amend.3, Annex7

"Quick Charge"
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ABSTRACT: Southern California air quality and transportation officials created the "Quick Charge" program with the goal of conducting a large-scale pilot demonstration of electric vehicles (EVs) within the jurisdiction of the South Coast Air Quality Management District, the smog control agency of the Los Angeles metropolitan region. The program seeks to identify and resolve potential barriers to EV commercialization. The EVs placed into service under the program will assist local communities, manufacturers, and utilities to test consumer demand and demonstrate the infrastructure, permitting processes, and coordination that are necessary prior to the introduction of larger quantities of EVs.

This paper will address the structure of the "Quick Charge" program, including a discussion on the current and planned activities to be performed between 1996, 1997, and 1998. The funding mechanisms and partners for these various activities will also be discussed. The "Quick Charge" program is a model for establishing EV-ready communities.

1. INTRODUCTION

The topography and climate of Southern California combine to make the Los Angeles Basin an area of high air pollution potential, constraining local efforts to achieve clean air. During the summer months, a warm air mass frequently descends over the cool, moist marine layer produced by the interaction between the ocean's surface and the lowest layer of the atmosphere. The warm upper layer forms a cap over the cool marine layer and inhibits the pollutants in the marine layer from dispersing upward. In addition, light winds during the summer further limit ventilation. Furthermore, sunlight triggers the photochemical reactions which produce ozone. The region experiences more days of sunlight than any other major urban area in the United States except Phoenix, Arizona.

The federal Clean Air Act and the California Clean Air Act require local air quality officials from the South Coast Air Quality Management District (AQMD) to reduce air pollutants within its jurisdictional area. The 1990 federal Clean Air Act Amendments identified the Los Angeles area as the worst ozone city in the country. The Basin is classified as "extreme" non-attainment for ozone, and "serious" non-attainment for carbon monoxide and fine particulate matter (PM_{10}) in accordance with the federal Clean Air Act. In addition the LA Basin contributes about 3% of the world's total global warming gases.

Local on-road motor vehicles account for 55% of the sources of emissions in the Basin. Table 1 shows the 1990 daily emissions inventory for on-road mobile sources, specifically volatile organic compounds (VOC), nitrogen oxide (NO_x), carbon monoxide (CO), and particulate matter (PM_{10}).

Table 1
Daily Average Emissions from On-Road Mobile Sources (Tons/day)

VOC	NO_x	CO	PM_{10}
761	762	5,342	70

The AQMD's 1994 Air Quality Management Plan (AQMP), calls for significant EV market penetration as a major strategy for improving local air quality. The "Quick Charge" program is aimed at determining and then overcoming market barriers. This paper will discuss the program's current and planned activities to be performed between model years 1996-98.

1.1 Troublesome Trends Population in the Basin has increased dramatically since World War II, and currently approaches 14 million - about half the population of the state of California. That population is expected to increase nearly 30% to more than 17 million people by 2010. Especially significant is the increase in the number of automobiles and vehicle miles traveled (VMT). There are over 9 million vehicles in the Basin today; with expected growth swelling to over 12 million by 2010 [see Figure 1]. Daily VMT in the Basin in 1994 was 284,984,000, and is expected to grow by 35% by the year 2000 [see Figure 2]. The Basin is also home to one of the most vibrant economies in the world. The challenge to the AQMD has been to develop strategies that balance the needs of an increasing population and an expanding business community, while meeting environmental goals.

Figure 1
Population & Vehicle Growth

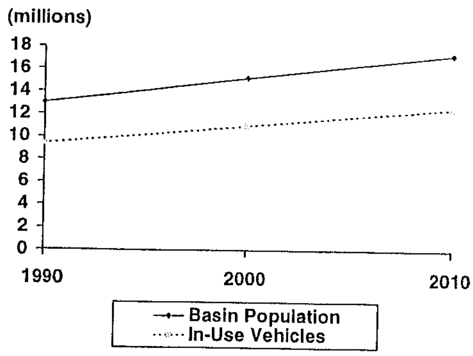
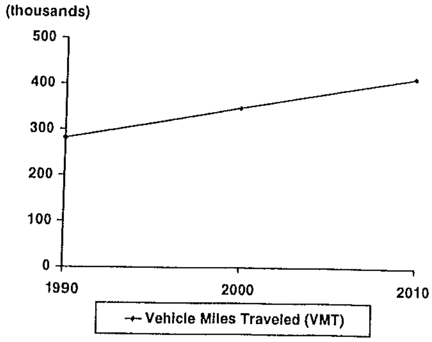
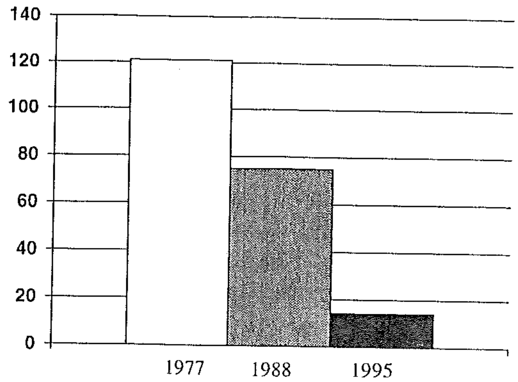


Figure 2
Growth of Vehicle Miles Traveled



The AQMD's efforts to improve air quality in the Basin have been successful. In 1977 there were 121 Stage 1 ozone episodes. Stage 1 episodes occur when air quality is considered very unhealthful. In 1988, there were 75 Stage 1 episodes. Southland residents endured 14 Stage 1 episodes in 1995. Figure 3 illustrates the dramatic reductions achieved since 1977.

Figure 3
Progress in Reducing Stage 1 Episodes



The South Coast Air Basin still exceeds standards for ozone, carbon monoxide, and particulate matter under ten microns (PM_{10}). The emissions of volatile organic compounds and oxides of nitrogen in the South Coast Air Basin must be reduced by 70% to 80% in order to attain the federal ozone standard.

With the spiraling increase of vehicles and VMT, and the fact that 55% of the Basin's air pollution can be attributed to motor vehicles, the AQMD faces large challenges in its efforts to reduce the Basin's air pollution inventory. An important element of the AQMD's programs to reach attainment is the use of zero emission vehicles.

The issue is also not one of just demonstrating air quality attainment. Maintenance of acceptable air quality while vehicle use and economic activity increase is also necessary. Decades of experience suggest that successively cleaner internal combustion-powered vehicles are still not clean enough as they are maintained and driven. Reducing emissions from in-use vehicles is the short-term "key" to reducing urban air pollution. A likely technology to attain and maintain healthful air quality is ultimately the zero emission vehicle.

1.2 Motor Vehicle Control Strategies In the transportation sector, the AQMD's goals are based on the California Air Resources Board (ARB) three-part plan for major motor vehicle control. This plan includes:

- Reduction of in-use vehicle emissions through smog-check, roadside smoke testing, and similar programs.
- Adoption of increasingly stringent standards for new vehicles.
- Promotion of the use of cleaner fuels in motor vehicles.

The AQMD has set ambitious goals for achieving federal clean air standards in the early part of the next century. A key to reaching these goals is the use of electric, reformulated conventional, and alternative fuels in the transportation sector. Table 2 illustrates the 1994 AQMP goals as a percentage of VMT in 2010.

Table 2
1994 AQMP Targets for
Electric and Alternative/Reformulated Fuel
Penetration as a Percentage of VMT

Vehicle Class	EV	Alt./Ref.
Passenger Cars	22	78
Light-Duty Trucks	15	85
Medium-Duty Trucks	0	100
Heavy-Duty Trucks	0	100
Urban Buses	30	70

These assumptions depend on the continued development of vehicle technology. A key to the overall plan to reduce motor vehicle emissions is the continued implementation of ARB vehicle and fuel standards that require manufacturers to make available the cleanest products, including zero-emission vehicles.

The air pollution benefits of EVs are immediately apparent - there is no tailpipe, no fumes, zero emissions. Even when taking into account the pollution produced by fuel oil or coal power plants generating the electricity for the "fuel" for EVs, they are still considered 90% cleaner compared to their gasoline counterparts. In the South Coast Basin EVs are considered 97% cleaner principally because of the local natural gas burning electric power plants.

Another incentive to the use of EVs is the federal Energy Policy Act of 1992 (EPACT), which includes provisions for the required use of alternative fuel vehicles by fleets. Federal and California State government fleets have aggressively pursued implementation of alternative fuel vehicles in their own fleets. Although local government and private fleets are not yet required to integrate alternative fuel vehicles into their fleets, many are buying today to determine the best technologies for their fleet needs, demonstrate leadership, or enrich their corporate image. EPACT also established an income tax credit for EVs to both businesses and individuals, available through December 31, 2004 (IRS Publication 535: Business Expenses). The credit cannot exceed $4,000 or 10% of the vehicle cost, whichever is lower.

The remainder of this paper will discuss the partnership between air quality officials and various local agencies to bring about the successful development, demonstration and eventual commercialization of EV technology with the creation of the "Quick Charge" program.

2. THE PARTNERS

2.1 Technology Advancement Office Senate Bill 2297 (Health & Safety Code Section 40448.5) created the AQMD's Technology Advancement Office (TAO) in 1988 to expedite the research, development, demonstration, and commercialization of advanced emissions control technologies and clean-burning fuels. State law allows for the imposition of a $1 motor vehicle registration fee to finance the program. The TAO operates with an average annual budget of around $8 million which it invests into motor vehicle technology projects with other government agencies and the private sector.

The TAO has pursued the development and demonstration of alcohol, natural gas and propane engine technologies; development of battery technology; demonstration of state-of-the-art electric drivetrains; establishment of alcohol fuel infrastructure; and the development and demonstration of fuel cell technologies.

This cooperative government-industry program is an integral part of the AQMP and now about one quarter of a billion dollars has been invested in progressively cleaner technologies and fuels. Approximately $45 million has been contributed by the AQMD to TAO's public-private partnerships.

2.2 Mobile Source Air Pollution Reduction Review Committee In September of 1990, Assembly Bill 2766 was signed into law (Health & Safety Code Section 44220-44247). This legislation authorizes the imposition of a motor vehicle registration fee of $4 to fund the implementation of programs to reduce air pollution from motor vehicles pursuant to the AQMP and provisions of the California Clean Air Act.

Collection of the fees were authorized by the AQMD in 1990. The moneys collected are distributed by the AQMD in the following manner: thirty cents of every dollar is used by the AQMD to carry out planning, monitoring, enforcement and technical studies; forty cents of every dollar is distributed to cities and counties located in the South Coast Air District; and thirty cents of every dollar is deposited into a "Discretionary" account to be used to implement innovative and competitive programs to reduce motor vehicle air pollution.

To determine which projects should be funded by the "Discretionary" account moneys, AB2766 authorized the creation of the Mobile Source Air Pollution Reduction Review Committee (MSRC). The MSRC designs and implements an annual Work Program of projects designed to reduce motor vehicle emissions. The final Work Program is submitted to the AQMD Governing Board for final approval.

By statute, the following public agencies are represented on the MSRC and/or its Technical Advisory Committee (TAC):

- California Air Resources Board (ARB)
- California Energy Commission (CEC)
- Cities of Los Angeles County
- Cities of Orange County
- Cities of Riverside County
- Cities of San Bernardino County
- City of Los Angeles
- Los Angeles County Board of Supervisors
- Los Angeles County Metropolitan Transportation Authority (LACMTA)
- Orange County Transportation Authority
- Regional Rideshare Agency
- Riverside County Board of Supervisors
- Riverside County Transportation Commission
- San Bernardino Associated Governments
- San Bernardino County Board of Supervisors
- South Coast Air Quality Management District
- Southern California Association of Governments

The average annual funding for the Discretionary Funds program is $12 million. To date, much of this funding has been used to support the re-powering and purchase of alternative fuel vehicles. A particular emphasis has been heavy-duty vehicles, and the program has facilitated the purchase of several hundred alternative fuel transit and school buses, garbage trucks, tractor-trailers, and other heavy-duty vehicles by funding incremental costs.

2.3 Southern California Edison One of the major electric utilities in the South Coast Air Basin is Southern California Edison (SCE). SCE began supporting EV product development beginning in the mid-1980s. In September, 1991 SCE created its Electric Transportation Division to focus on the emerging technology and market. Since then SCE has assisted in the creation of the Infrastructure Working Council (IWC), as well as the United States Advanced Battery Consortium (USABC).

On November 21, 1995, the California Public Utilities Commission (CPUC) issued a decision on Edison's LEV funding application enabling the utility to support and promote electric transportation within its service territory. SCE is authorized to spend nearly $44.7 million over six-years (through 2002) for EV-related programs. SCE must concentrate its resources in the following areas:

- System Impact Analysis/Assessments
- Infrastructure Research & Development
- Model EV Fleet
- Utility System Upgrades to Support Infrastructure Installations
- Technology Introduction & Customer Education

2.4 Municipal Electric Utilities The Los Angeles Department of Water and Power (LADWP) is helping lead the effort by local municipal electric utilities to make the South Coast Air Basin "electric-vehicle-ready" through the development and support of an advanced electric transportation industry. LADWP has installed more than 100 charging stations in its service territory. LADWP was also among the first utilities in the nation to establish a discounted EV charging rate when it implemented one in January 1991. Additional municipal utilities who have begun similar programs include Riverside, Anaheim, Burbank, and Glendale. The various municipal utilities have joined with SCE to create the Utility Working Group which seeks to develop mutual strategies which encourage the commercialization of EVs within each of their respective jurisdictions.

3.0 "QUICK CHARGE"

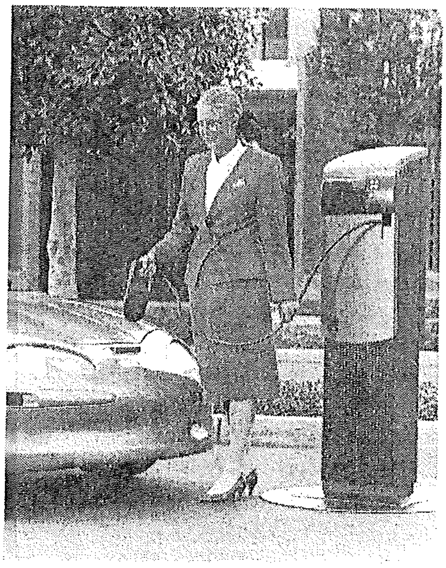
In July 1995, the AQMD's Governing Board unanimously approved the recommendation of the MSRC to create the "Quick Charge" program. The goal of the "Quick Charge" program is to conduct a large-scale pilot demonstration of EVs within the jurisdiction of the AQMD during 1996, 1997, and 1998. This demonstration will aid local communities, manufacturers, and utilities to test the consumer market and demonstrate the infrastructure, permitting processes, and coordination that would be necessary for the eventual introduction of larger quantities of EVs.

The pilot demonstration seeks to identify and resolve potential barriers to broad EV commercialization. Among the various issues to be addressed are the following:

- Charging Methods
- Codes and Standards
- Consumer Education and Training
- Emergency Response Training
- Equipment Availability
- EV Service Capability
- Fast Charging
- Home Charging

- Incentives
- Permitting
- Remote Charging
- Utility Capacity
- Utility Electric Rates

3.1 EV Manufacturer RFQ In order to encourage manufacturers to voluntarily provide EVs for the pilot demonstration, the MSRC has made available up to $6 million for consumer incentives to be used to buy-down the manufacturer suggested retail price (MSRP) or lease capital cost of qualified EVs. The incentive is meant to assist manufacturers in pricing early EVs in a manner that will bolster their commercialization. In order for a manufacturer to qualify a vehicle model for the incentive, the model must meet strict performance and safety requirements based upon EV America Phase Two Specifications. In some cases, the requirements are stricter than those outlined within the EV America criteria. Manufacturers must commercialize, repair and maintain the EVs within the South Coast Air District for the duration of the program. Further, the MSRC is asking for only models which have a base-price MSRP below the federal luxury tax trigger, currently around $34,900. These requirements were defined in a Request for Qualifications (RFQ) package and released in December, 1995.

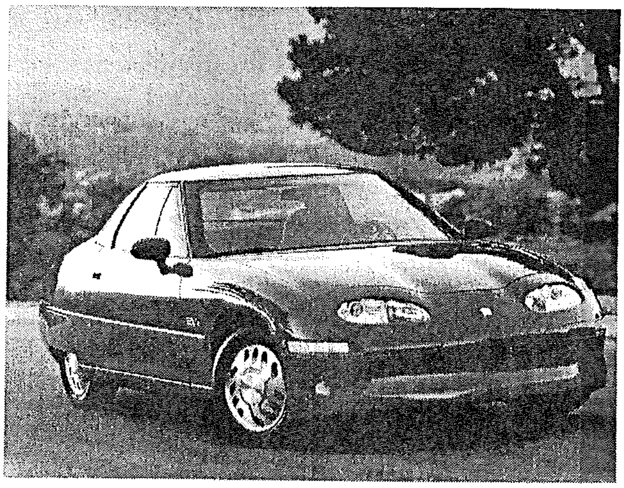


Picture 1 - Charging the new EV_1

The manufacturer incentive is capped at $5,000 per EV and will be distributed once actual sales and/or leases have been verified. The EVs must principally operate within the AQMD's jurisdiction in order to receive the incentive. Incentives will be offered until the designated funds are exhausted, reprogrammed, or reach the program expiration date of December 31, 1997. The MSRC has received inquiries from both foreign and domestic auto makers and expects to qualify one or more EV models beginning July 1, 1996.

On January 4, 1996 General Motors Corporation announced its intention to be the first major auto maker in modern times to market a purpose-built EV to the public, the EV_1 [see Picture 2]. The two-seat EV_1 will be sold through Saturn retailers and will later be joined by Chevrolet when the S-series electric pick-up truck is made available to fleets nationwide beginning in 1997 [see Picture 4].

The EV_1 and Chevrolet S-series will initially utilize Delco valve-regulated lead-acid batteries, but will be fully capable of being upgraded to advanced nickel metal hydride (NiMH) batteries as early as 1997. The NiMH batteries are being developed by Ovonic Battery Company (OBC) and Delco Propulsion Systems (DPS). DPS is working with Valence Technologies in Nevada to develop automotive lithium-polymer (Li-Polymer) batteries.



Picture 2 - General Motors EV_1

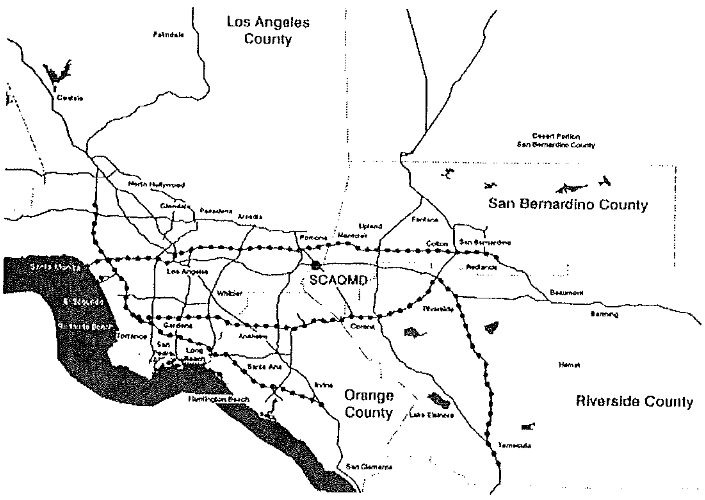
Ford Motor Company has indicated that they will be offering an electric Ranger pick-up truck, as part of their Qualified Vehicle Modifier (QVM) program for model year (MY) 1997, followed by their own in-house electric Ranger for MY 1998 [see Picture 5]. The 1997 model will be built by Transportation Design and Manufacturing Inc. (TDM) of Livonia, Michigan. TDM is strategically supported by Ford, Westinghouse, and GNB. Chrysler plans to continue with its electric minivan program, the Electric Powered Interurban Commuter (EPIC).

In 1997, both Toyota Motor Sales, USA and American Honda Motor Company plan to market small numbers of their electric test vehicles in an effort to gather additional EV performance and marketing data.

Toyota announced plans to market approximately 320 electric-powered RAV4 sport utility vehicles to fleet buyers beginning in the 1998 model year (see Picture 6). The Toyota RAV4-EV will be equipped with a Matsushita-equipped advanced NiMH battery pack. These plans will follow Toyota's current in-depth on-the-road test program which began in early 1996 with seven pre-production RAV4-EVs being placed with utility companies in California and New York.

American Honda has unveiled a purpose-built EV, which operates on advanced NiMH batteries. Honda plans to lease approximately 300 of the Honda EV (see Picture 7) to both fleets and individual consumers in California, beginning in Spring 1997. Honda will offer a "turn-key" lease program that will cover such major items as maintenance, insurance, roadside assistance and battery replacement. The announcement follows Honda's California fleet program, in operation since 1994, with the prototype Clean Urban Vehicle (CUV-4). More recently, Honda began evaluating the CUV-4 as an airport rental car with the National Rental Car company.

Nissan Motor Company Ltd. has two EV concepts: the two-seat FEV-2 and a four-seat Prairie Joy EV. Nissan will begin a limited sales/lease program in Spring 1997 in Japan for the Prairie Joy EV, which has lightweight, high energy storage capacity lithium-ion (Li-Ion) batteries developed by the Sony Corporation. This EV has adopted the Magne Charge™ inductive charging system and a permanent-magnet synchronous motor design. Nissan plans to introduce a newly developed vehicle with Li-Ion batteries, targeted for California fleet users, in early 1998. Nissan will continue to conduct California road testing under local climatic conditions through 1997.



Picture 3 - South Coast Air Basin Freeway System with EV Corridors noted with ♦

3.2 EV Corridor Communities Program Concurrently the MSRC has initially allocated $1,600,000 to be leveraged with local funding to create "Quick Charge" EV Corridor Communities. This program supports the deployment of EVs along designated freeway corridors and within specific communities that have committed to be "EV-ready" (see Picture 3). Local government will play a critical role in permitting/inspection, adopting codes and ordinances, and providing public recharging infrastructure.

3.3 Outreach Coordinator The MSRC also approved a $175,000 award to "The Planning Center" to act as an outreach coordinator for the demonstration. The outreach coordinator has assisted cities in their response to the EV Corridor Communities solicitation. Concurrently, this team has worked with local electric utilities and other cities to coordinate their efforts. The outreach coordinator established a utility working group with the goal of sharing existing knowledge and experience on the "utility side" of the meter (i.e. distribution upgrades, metering, rates) as well as identifying "customer side" issues (i.e. charger, service panel, raceway, receptacle).

3.4 Advanced Charger Demonstrations The TAO may augment "Quick Charge" funding in the form of advanced charger demonstration projects. Both forms of advanced chargers are being investigated, conductive and inductive. A competitive solicitation will likely be released for charger demonstrations in Fall 1996. A formal proposal has been received by the TAO from Delco Electronics Power Control Systems. The TAO is considering a joint development and demonstration of the inductive charger technology within the Basin.

The GM EV_1, the Chevrolet S-series, Nissan's Prairie Joy and possibly the Toyota RAV4, as an option, will use the inductive charging system developed by Delco Electronics Power Control Systems. Power Control Systems located in Torrance, California pioneered the inductive charging technology and has begun low-volume production of 6.6kW standard charging units. Other manufacturers are pursuing a standardized conductive plug and charger design for their respective vehicles but specifics have not yet been announced.

During the next three years, five announced and interrelated infrastructure projects will be undertaken by charger manufacturers, utilities and cities throughout the AQMD:

- Component reducing improvements and a public infrastructure demonstration of the inductive, single-phase 165 to 240 VAC, 6.6kW standard charger [see Pictures 1, 8 and 9].
- Fast track development of low-cost installation procedures for the standard residential chargers.

- Development and fleet demonstration of high power chargers (25kW and 50kW) with a limited public infrastructure demonstration [see Picture 10 for the inductive Power Control Systems three-phase 480 VAC, 25kW charger].

- Development of public charging automated billing systems.

- Development of load management firmware to provide wide area network communications between chargers and the utility secondary grid system.

3.5 Edison EV On January 17, 1996, in a move to rapidly bring charging convenience to EV owners, SCEcorp announced the creation of a new company, Edison EV, to sell, lease, install and service residential and commercial charging systems for EVs. The new company has created a unique partnership with General Motors, offering one-stop availability of equipment and installation services to GM EV_1 customers initially through participating Southern California Saturn retailers. Edison EV seeks to provide a simple, one-stop answer for the charging needs of new EV owners. Without Edison EV, customers would be faced with the following time-consuming and confusing tasks: finding a reliable contractor, establishing costs, coordinating with the local utility, and coordinating with permitting agencies. Edison will perform these tasks, as well as provide maintenance, repair service, and warranties for the charging systems.

Edison EV will also be the California distributor of Magne Charge™ inductive charging systems produced by Delco Electronics Power Control Systems. Edison EV has also stated that they will work with other charger vendors, both conductive and inductive, on a plan to pre-qualify electric contractors to perform charger installations, both residential and public, throughout the United States.

4.0 SUPPORT PROGRAMS

4.1 Training The TAO, the California Energy Commission (CEC), SCE, and the ARB are assisting the California State Fire Marshal's Office in developing an EV training program for emergency response personnel including medical, law enforcement, and fire service. Secondly, CEC, in conjunction with the California State Building Standards Commission (CALBO) has conducted local workshops for contractors to highlight EV-related Article 625 Revisions to the National Electrical Code.

4.2 Advanced Battery Demonstration On March 29, 1996, the ARB approved modifications to its zero-emission vehicle (ZEV) program. The original program began with model year 1998 and required large-volume manufacturers to produce and deliver ZEVs, likely EVs, for sale in quantities equal to two percent of their new light-duty vehicle sales. This percentage requirement was to increase to five percent in 2001 and ten percent in 2003. While the ARB opted to maintain the 2003 percentage requirement, the ARB entered into a Technology Development Partnership consisting of separate memorandum of agreement (MOA) with each of the seven largest auto manufacturers for EV products and for demonstration of advanced battery ZEVs in the near-term.

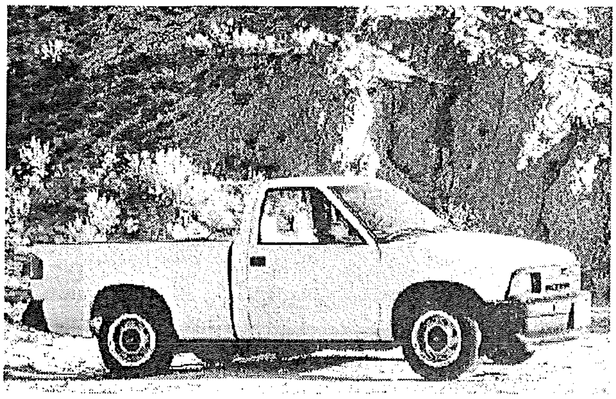
The purpose of the Technology Development Partnership is to promote the development and demonstration of advanced battery technologies in real-world applications. In late-Spring 1996, the AQMD's Technology Advancement Office, in conjunction with the ARB, CEC, MSRC, and SCE, initiated the Advanced (Battery) Electric Vehicle Demonstration Working Group to develop the framework and funding mechanisms for projects to support the Technology Development Partnership. The objective of the projects would be to obtain information on the consumer acceptance, use patterns, operating costs, and other data concerning advanced battery electric vehicles. The demonstration would be designed to compare current and advanced battery chemistries and technologies in a variety of topographic and climatic conditions.

5.0 CONCLUSION

Incorporation of EVs into Southern California's transportation mix is an important component in the AQMD's plan to achieve healthful air quality by 2010. The "Quick Charge" Program is a public-private partnership designed to overcome barriers to the broad introduction and commercialization of EVs. Working with the auto makers, state and local agencies, electric utilities and others, the "Quick Charge" Program will jumpstart the South Coast EV marketplace.

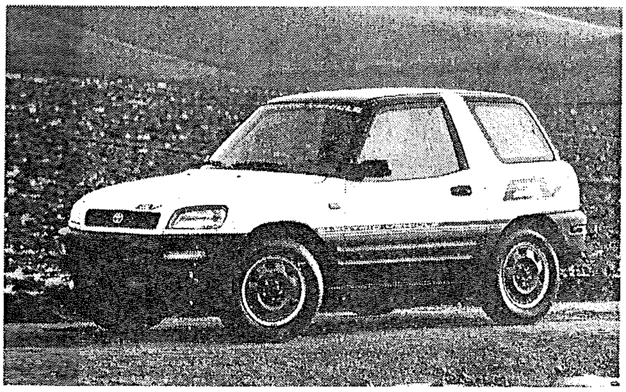
Efforts are also underway to duplicate the program in neighboring jurisdictions, specifically in San Diego, Santa Barbara, and Ventura Counties.

Future conference papers will provide updated information on the various elements of the "Quick Charge" program.

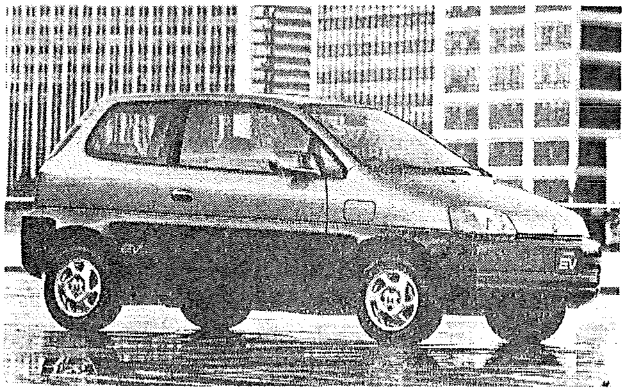


Picture 4 Chevrolet S-Series pick-up truck

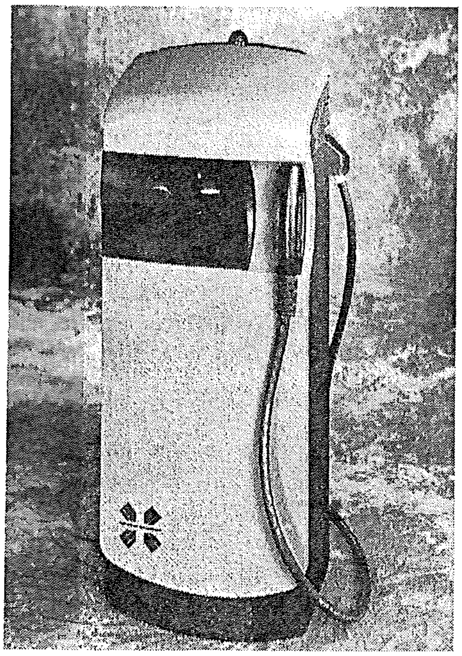
Picture 5 Ford Ranger pick-up truck



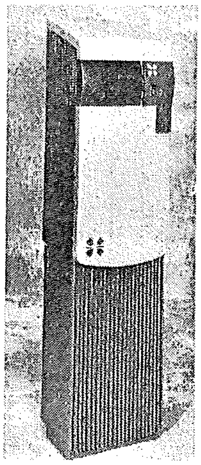
Picture 6 Toyota RAV-4



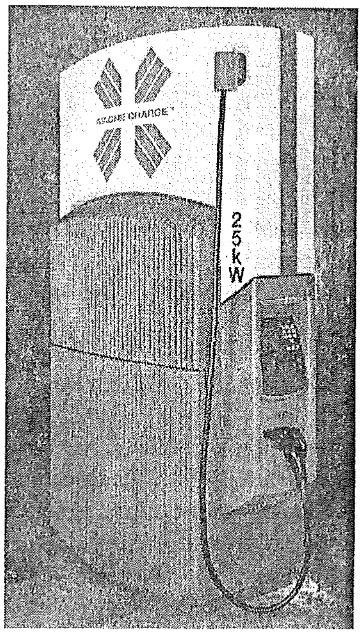
Picture 7 Honda EV



Picture 8 Standard Charge Module Wall Mount



Picture 9 Standard Charge Model, Floor Mount



Picture 10 Opportunity Charge Station