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能源与动力学院

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能源与动力学院

022 系

023 系

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Training of Qualified Personnel--Booster of the Development of Electric Vehicles

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Abstract

In this paper the author divides the development of EV in China into two stages according to its characteristics taking 2000 as the dividing line. After reviewing the role of universities in China's EV development in the first stage, the author goes on to point out that in second stage universities should pay more attention to the training of EV technical personnel for the auto businesses while continuing to do EV research and provide technological support for businesses. The author also proposes a knowledge structure and syllabus fit for the training of EV personnel.

Keywords: Electric Vehicle, Education, Training

1 Introduction

It has been twenty years since some insightful people began to introduce EV from abroad to China and some non-governmental organizations began to modify ordinary vehicles into electric powered vehicles. Broadly speaking the development of EV in China can be divided into two stages taking the end of 2000 as the dividing line. Before the end of 2000, that is the first stage of Chinese EV development, China's EV research was characterized by theoretical exploration and universities and research institutions were responsible for. Their studies which were conducted in the laboratories of universities were far away from the market. During that stage the central government and local governments only provided little sporadic funds for the development of EV although it was included in the eighth and the ninth Five-year National Economic Plan. Beginning from 2001, however, much greater attention has been paid to the development of EV both financially and institutionally. It is now included in the tenth Five-year Plan starting from 2001 as a major research and development project with a fund of 0.9 billion RMB yuan. Automobile makers, universities and research institutes form a market-oriented united front with a view to lay a technological basis for the production of EV in the next five to ten years.[1]

At the second stage the goal is clear-cut: to produce and commercialize EV and HEV with the automobile makers taking the lead and universities and research institutions providing technical support. During the first four years of the second stage, some problems concerning the development and production of EV have kept arising. In order to ensure the successful fulfillment of the set goal and accelerate the production of EV in China, it is necessary to review and sum up the successes and failures of the first stage so that both the universities and the automobile makers know better their respective new roles.

2 The role of universities in the 1st stage of EV in China

The development of EV in China can be traced back as early as the 40s of the last century when an experiment on EV was made in Chongqing, one of the biggest cities in southwest China. In the 50s and 60s, more experiments were made intermittently, of which the most influential was the one in 1962 when a SWD-S2 mini-EV was successful developed by Shanghai Public Utilities Research Institute. This model was intended for taxi use with an average speed of 28.4km/h and could drive 82 km by one full charge. All these dreams and efforts which lasted for several decades and generations are after all ephemeral prior to the booming of the EV development in China.

The catalyst for development of modern EV was the automobile pollution of the 60s of the last century and the oil crisis brought by the Mid-Eastern War of the 70s and its milestone was the First World Electric Vehicle Symposium (EVS-1) held in Phoenix City in the United States. At that time the Cultural Revolution in China was not over and economic construction was in a state of chaos. Like many other manufacturing industries, automobile industry was almost at a standstill. It was not until the 80s that China扟 auto industry began to develop vigorously. With their sensitivity for new technology, their insight for the automobile development trend and their information from abroad, some university professors and thoughtful people called for a start of our own EV development for the protection of our environment, for the sake of our resources and to catch up with the advanced automotive technology.

Undoubtedly December 1987 when Electric Vehicle Institution, Chinese Electro-technical Society was founded marks the beginning of the development of China扟 modern EV. Although the Electric Vehicle Institution is an academic group consisting of representatives from universities, businesses and research institutes, it is not only a saloon for technological and academic exchanges, but also a place for those who are interested in EV to exchange information and to exert influence on the government. Since that time, the research projects that used to be scattered in different parts of the country converged into a unified national force for the development and production of EV. The first stage from 1987 to 2000 was a time of understanding EV, gaining and accumulating experience. Like all the beginning stories in every other country, at first lead-acid batteries, DC brush motors and choppers were used to replace the engines and tanks in the model vehicles. The initial prototypes could be driven by electricity instead of fuel even though they were not so efficient. And then AC motors with inverters, NiMH and Li-ion batteries were used to reduce weight so as to improve the efficiency of the prototypes. In order to make up for the inadequacy of specific energy of the available batteries, the research focus has since been shifted to HEV.

In terms of technology, the major task for the first stage was, on the one hand, to choose the power system and to test its design and, on the other hand, to examine the choosing, making and using of such key parts as the motor and battery. It is by nature a time to cognize whether EV could be the alternative of ICE vehicles. As the technical and research capacities of China扟 auto industries are very weak, whereas the universities are academically much stronger, the best way to develop modern EV is to combine the university laboratories with factory workshops. The last decade of the last century a lot of prototypes of EV were developed by several universities in China. All the prototypes have produced nationwide exemplary effect. Refer to list1 for the main prototypes of EV and HEV developed by several universities throughout China.

List 1 the main EV prototypes developed by Chinese universities during 1st stage

Prototype	Type	Developed by	
U2001	BEV car	Hong Kong University	1993
EV6580	BEV Medium Bus	Tsinghua University	1995
EV6630	BEV Medium Bus	Southern China University of Technology	1995
YW6120DD	BEV Full Size Bus	Beijing Institute of Technology	1996
ZJ6705HEV	SHEV, Medium Bus	Jiangsu University	2000

The technological support of the universities gave some automotive makers confidence to start the development of EV. To sum up, the development of EV in China underwent the initial technological exploration and the gradual maturation. These changes can be clearly observed from the following statistics of the publications of articles on EV by professors in the major journals in China from 1992 to 2000. [2][3][4] See Figure 1 and Figure 2.

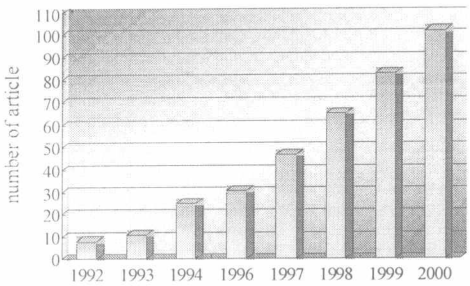

Fig1 The number of EV articles in the major Chinese journals during the 1st stage

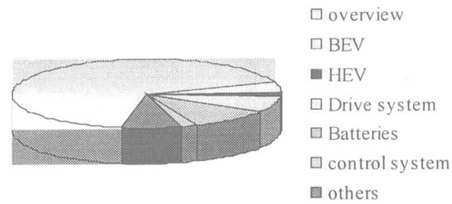

Fig2 The statislics of the EV articles classification

Although up to 2000, there were only dozens of prototype of EV and no more than ten prototypes of HEV throughout China, the research on EV has achieved desirable result as shown below:

Firstly, several years research has facilitated users understanding of EV so that both the government and auto industries agree that EV are the best way to reduce exhaust pollution and oil consumption and that an inevitable trend will be the mass production and widespread use of EV. The development of EV in China is now on its way to success.

Secondly, the development of prototype EV in the past ten years has not only stimulated the development of EV by China抯 major auto industries but also promoted the development of key spare parts and brought together spare parts businesses which in turn offer support for the further development of EV.

Thirdly, the government has started to consider a comprehensive plan of EV and is making related policies and various standards to encourage and push the development of EV and planning the infrastructure and trial operation. Finally, many universities are beginning to train people for the development of EV.

3 The role of universities in the commercialization of EV

As a commercial product, EV should be developed and produced only by industries which can carry out the commercialization of EV according to the market laws. But during the first stage, China did not have a rich accumulation of EV technologies; the technology for the key parts was not practicable and reliable; there was a lack of experience in the development and operation of HEV; the designing and analyzing methods were backward. In view of these practical problems, the EV Development Key Project which is also called 863 Project in the Tenth Five-Year Plan was set. [1] With the help of the Project, Chinese enterprises, universities and research institutes are integrated in one to conduct R&D of EV. The tasks of the Project are to realize the mass production of hybrid vehicles, push forward the BEV commercialization, establish FCEV technology platform as well as to form the industrial base of EV components & accessories.

The preliminary goal for the Project has now been reached in the form of prototypes of EV and HEV. See List2 for the progress of some sub-projects. [1][5]

List 2 The Progresses of EV sub-projects of "863

Prototype	Type	Developed by	Operation
EQ61100HEV EQ7200HEV EQ7200EV	PHEV, transit bus PHEV, sedan BEV, car	Dongfeng Motor Co. Ltd	As BUS-509/510 trial operation in Wuhan
JF61100HEV HQ7200HEV	HEV, full size bus PHEV, sedan	FAW	
Chunhui-1	FCEV, sedan	Shanghai Motor	

Suepass-1	FCEV, sedan	Group Co. Ltd	
BJD6100-EV BFC6100-EV	BEV, transit bus BEV, city bus	Beijing Institute of Technology	As BUS-121 trial operation in Beijing
TH6100	FCEV, full size bus	Tsinghua University	
Xiali7200EV	BEV, car	Tianjing FAW	
QR7200HEV ZC7050A-EV	PHEV, car BEV, car	Chery Automobile Co. Zhaocheng EV Co.	

In the above-mentioned development projects by some auto factories, the research on some key technologies is done by some universities. For example, in the HEV bus project by FAW, Jilin University was responsible for the development of power train controller. Huazhong University of Science and Technology was responsible for the development of switched reluctance motor drive train of hybrid electric transit bus by Dongfeng Motor Co. Ltd. And the development of the control system in the EV sedan by Cherry was undertaken by Shanghai Jiaotong University. It can be seen from List 2 that the development of FCEV and pure electric transit bus was undertaken respectively by Tsinghua University and Beijing Institute of Technology. In the past four years of the second stage, more and more universities in China (more than twenty) have been involved in the research on EV; more than 1000 articles have been published.[2][3][4] See Figure 3 for the distribution of the contents of these articles.

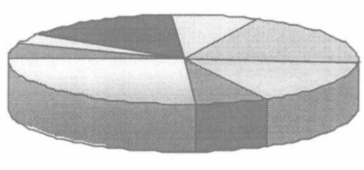

Fig3 The statislics classification of EV articles in the major Chinese journals during 2001 to 2004

People may very well expect that universities will continue to get involved in the development of prototype EV or even in their commercialization. What has been neglected, however, is another important role that universities may play in the development of EV, i.e. the training of people.

4 The training of people for the commercialization of EV

In the past decade, the technology of the automobiles produced in China has greatly improved as a result of the joining of many world famous auto industries with the auto industries in China. `Yet, the training of the technical personnel for the auto industries in China抯 universities and colleges lags far behind the improvement of the auto products. The main reason is that such courses as mechanic engineering accounts for the most part in the syllabus for the automobile major while basic courses such as electricity, electronics, computer science and automatic control account for only a very small part. What's more, introduction to the latest automobile electronics is scanty. The outdated knowledge structure of the students not only makes the auto personnel unqualified but also affects the development and commercialization of the electric vehicles in China.

During the first stage, the training of the technical personnel for EV in the universities was unplanned. Actually, in many of the EV projects sponsored by various universities, many graduate students worked as professors assistants. Some of them learned some related basic courses for EV and all of them learned a lot during their participation in the prototype development. Some of them even decided to work in auto industries which are undertaking EV development. Now they are putting what they learned in school to the commercialization of EV.

It is essential to have an army of technical personnel who are equipped with the basic knowledge about EV if EV will be commercialized in China. Several automotive makers and universities have known this requirement. Course *Electric Vehicle*' has been started for advanced undergraduates in several Chinese universities in 90s. Except some handout notes used in some universities few of EV books which were published these years were take as textbooks. The main EV books in Chinese published during 1997 to 2003 are listed in List3.

List 3 Textbooks of Electric Vehicle in Chinese

Title	Author	Publisher	Publishing date
Electric Vehicle	Fengchun Sun, Chengnin Zhang, et.al	The Press of Beijing Institute of Technology	Jan.1997
On Electric Vehicle	Quanlai Liao, Rongqing Huang	The Press of Southern China University of Technology	1997
The Key Technologies of Electric Vehicle	Peilin Wan	The Press of Beijing Institute of Technology	Dec.1998
The Green Means of Transportation -- Electric Vehicle	C.C. Chen, Yiju Zhan	Tsinghua University Press, Jinan University Press	June,2000
The Fundamentals of Hybrid Electric Vehicle	Antoni Szumanowski	The Press of Beijing Institute of Technology	Nov.2001
The Technology of Modern Electric Vehicles	C.C. Chen, Fengchun Sun, Jiaguang Zhu	The Press of Beijing Institute of Technology	Nov.2002
Electric Vehicle	Hua Hu, Hui Song	People's Traffic Press	Jan.2003

The most of the books in List3 just provided narrative descriptions of EV, HEV and their components. But the engineers of today and tomorrow should be educated in the technical details of these vehicles. From the survey of several universities the present courses mostly include only EV which is either in its width or in depth far from satisfying the need for the technical personnel of EV commercialization.

The power train of EV/HEV is an excellent combination of electro-mechanical and electro-chemical system. The designers of EV and HEV must not only have the basic knowledge about dynamics, mechanics, thermodynamics, material science, electronics and computer science, but also know the basic theories about electric drive and electrochemistry. Therefore, the present syllabus for the automobile engineering needs radical change. The present author offers a supplementary course table which target at advanced undergraduates and graduates of vehicular engineering for reference. See List4

List 4 Supplementary Courses of Undergraduate of Automotive Engineering

Course	Main Content	Reference Textbook
Power Electronics and Electric Drive Principles	Power electronic devices, Converters, Mechanical – electrical energy transfer, The operation principles and control of electric motors	Ned Mohan, Electric Drives: An Integrative Approach, 2003, ISBN-09715292-1-3
Batteries of Electric Vehicle	Electrochemical fundamentals, Classification and structure of EV batteries, Operating characteristics of power batteries,	
Fuel Cell	Basic Principles, Thermodynamic Analysis, Water & Thermal Management in the PEM Fuel Cells	James Larminie, et.al, Electric Vehicle Technology Explained, 2003, ISBN- 0470851635
Single Chip Computer and Data Communication	Single chip computer, Language program design, Hardware and software design, Data networks in	

	vehicle, Communication protocol	
Modeling, Simulation and Control of HEV	Modeling fundamentals, Simulation software, Principles of optimization applied to HEV modeling and Control	
Design fundamentals of EV and HEV	Introduction to EV/HEV/FCEV, Batteries, Power electronics and motor drives, EV drivetrain, Generic control strategy of HEV,	Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, 2003, ISBN 0-8493-1466-6, CRC Press
Environmental Protection Tech. of Vehicle	Environmental Pollution of Vehicles, Combustion Pollutants, Measurement and Control of Automotive Emission	Xinghu Li, Environment Protection Tech. of Vehicle, 2004,7-81077-388-7BUAA Press
Technical-Economic Analysis of Vehicles	Cost Concepts, Elements of Economic Analysis, Costs and Price of Vehicle, Life Cycle Assessment	

In order to avoid that automobiles do harm to environment, we should take environmental protection as the basis for the designing, development and production of automobiles and the main assessment index. Therefore *Environment Protection Technology of Vehicle*' should be included as one of the courses so that the relationship between automobiles and environment will become an important part in the knowledge repertoire of the future auto engineers. As professionals, auto designers and engineers should take the responsibility for the health and safety of our citizens. The course "The Automotive Technological and Economic Analysis" is a comprehensive and overall evaluation of the technology, environment and economy of the whole life of EV or even all the automobiles from their production to their use and scrapping so as to show man扭interest and unremitting effort in the sustainable development. As a matter of fact the views and methods provided in this course could be used for the market prediction of EV and HEV so as to assist the government in working out reasonable and efficient policies to encourage EV production.

By opening a series of new courses to construct a system of courses that is in keeping with the development of modern technology and renew the knowledge structure of auto students, the present auto industry扭need for high-quality technical personnel would be satisfied. Apart from the training of university students, the in-service engineers should also receive short-course training to update their knowledge. Only in this way the lack of technical personnel for the development of EV in China will be overcome. Finally, attention should also be paid to the construction of laboratories for EV research and development and businesses should play a part in this respect.

The development of electric vehicles, hybrid electric vehicles and fuel cell electric vehicles are both economically and socially beneficial. Its greatest advantage is the marked improvement of the environment of human inhabitation on the earth. In the past few years, China leads the fastest development of the auto industry in the world and due to its population and area, China is very likely to become the biggest auto market. From this perspective, we can very well predict that China can play a vital role in the development of electric vehicles in the world. As a matter of fact, some foreign auto industries included TOYOTA and GM, have begun to contact China concerning electric vehicles. It can be expected that there will be positive results in the future. As an important part in international cooperation, the education and training of electric vehicle technologists will push the international cooperation in technology, production and even the marketing of electric vehicles.

5 Conclusion

From the above discussion we may conclude :

- During the first stage of China扭EV development before 2000, China扭universities And research institutes played the major role and during the second stage after 2001 China扭 major auto industries lead in the EV development. Technologically, China扭universities and research institutes are still playing an important role.

* The precondition for the smooth transition to the EV commercialization is to have sufficient qualified technical personnel. Universities should not only train undergraduate and graduate students to become qualified EV personnel but also provide training for auto

industries.

* University syllabuses for auto majors must be supplemented, the textbooks need to be revised and the laboratory facilities need to be upgraded.

* China扟 participation in EV personnel training is a need for global environmental protection.

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国外混合电动汽车发展的最新态势及其启发

—兼述 EVS-21 印象

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摘 要：本文就 EVS-21 上的展览、驾乘、学术研讨会和厂家的新闻发布会等所传递的信息，并结合从近来的其他媒体、国际会议以及国外厂家直接接触所得到的资料，概述国外混合电动汽车发展的最新态势以及主要关键部件蓄电池的研发动向。
关键词：混合电动汽车；锂电池；发展动态；EVS-21

一、序 言

EVS-21 于 2005 年 4 月 2 日至 6 日在摩纳哥隆重举行。这是自 2003 年底美国加州 EVS-20 以来，世界电动汽车新技术、新产品、新观念的大检阅、大交流。大会有来自 49 个国家和地区的 775 名注册代表，发表论文 288 篇，109 家参展单位带来四十多辆各种电动汽车概念车、样车、模型用于展览，以及几十辆电动汽车商品车供试驾试乘，还有许多电动汽车的关键部件的新技术、新产品供展示和交易。

会议期间除了宣读、讨论论文、样车展览、试驾试乘外，还有厂商的新闻发布会、热点圆桌会议等等。这些丰富内容集中体现了这一年多来世界电动汽车理念、技术和产所取得的新成就，并预示着电动汽车技术发展的新趋势。这些重要的信息和它们所蕴涵的意义值得我国电动汽车事业的发展参考。

二、混合电动商品车目前的发展态势

会展大厅内聚光灯下主要是各种燃料电池汽车样车，但代表们更有兴趣的是出现在驾乘现场的各个公司带来的混合电动汽车。其中丰田的 Prius-II 和本田的混合电动 Civic 已在不少车展和会议上露过面，但会议代表、参观者和市民仍兴致勃勃地踊跃驾乘体验。摩纳哥地域很小，驾乘路线自然不长，但参加驾乘的代表体会的不仅仅是这两款车操纵的灵活、乘坐的舒适，更在思索它们所代表的混合电动汽车的发展方向和市场前景。

丰田的 Prius 和本田的混合电动 Insight 是世界上最早推出的混合电动商品车。5 年来， Prius 累计销售十多万辆。Insight 前几年也占据了北美混合电动汽车市场的半

壁江山。有趣的是 Prius 和 Insight 恰恰代表了两种截然不同的混合方式，丰田 THS 系统和本田的 IMA 系统。THS 系统（TOYOTA Hybrid System）是具有两台电机，电动机与发动机功率相当，通过行星齿轮机构实现动力复合和分配的完全混合系统(参见图 1)。它的特点是能量流控制精细，机构比较复杂。IMA 系统(Integrated Motor Assist)是典型的轻度混合系统(参见图 2)，其中作为辅助动力的盘式电动机装在发动机与变速器之间，与曲轴同轴安装，功率较小。它的特点是系统简单，相比 THS 系统来说对传统驱动系统改变较少。生产成本的提高幅度也应较少。两种系统、两种车型都获得市场的初步成功。但大家更关心的是面向大批量市场这两种系统将会如何应对，它们的前景又如何呢？

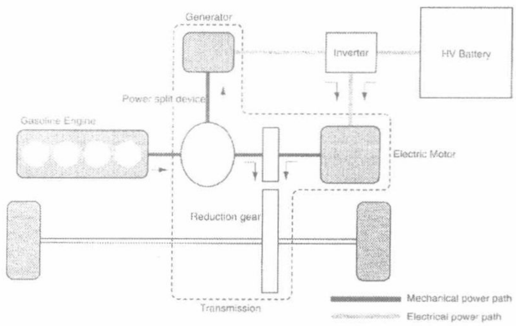

图 1 Prius 的 THS 系统

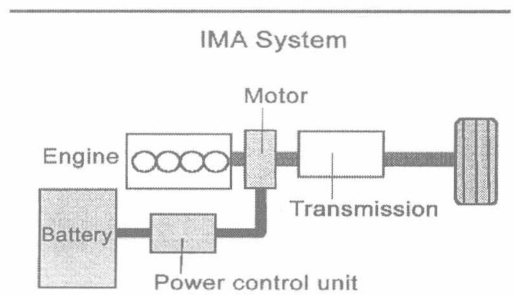

图 2 Civic 的 IMA 系统

不少人对这几年欧美市场中 Prius 供不应求而丰田公司迟迟不扩大产能所困惑。现在大致有了答案。不是不应市场的需求而扩大供应，而是需时间来解决存在的问题。要解决的两主要问题，一是可靠性，二是成本。一方面对丰田混联系统 THS 进一步完善，使之控制更为精细，成为发动机、电动机、蓄电池等各主要动力部件尽出其力、和谐配合更佳的 THS-II(又称为混合共能驱动)系统；另一方面是对影响整车整体可靠性和成本的蓄电池进行改进。丰田与松下公司及 Matsushita 公司合作，从材料、工艺等多方面对镍氢电池进行攻关，使得新的镍氢电池的输出功率密度较前提高了 30%；据此，又采用具有升压功能的电源转换器。该转换器可以将镍氢电池组的 201.6V 电压升至 274V～500V 范围内，从而变 Prius 的 38 节电池（273.6V）为 PriusII 的 28 节电池，仅此一项就节约了 10 节电池的成本，并降低了整车重量[1]。PriusII 就是 Prius 的全新改进型。

经过几年的批量生产，系统工艺的逐步成熟，再加上镍氢电池的质量升级，通过反复试验和这些年的用户使用跟踪，丰田公司对 PriusII 的质量、生产成本和维护成本有了足够的自信，丰田对 PriusII 的用户承诺：动力系统（包括蓄电池组）包用 8 年，保证行驶 16 万千米。据此丰田要在国内上第二条 PriusII 的生产线，并有了丰田与中国一汽于 2004 年签订的在中国生产 Prius 的备忘录。不仅如此，丰田还将其 THS-II 系统推广到它的混合电动车系队伍中的其他车型中去，见表 1。

尽管从 1997 年 Prius 作为产品车问世，THS 系统不断地有一些修改，但丰田公司一直恪守 THS 这一自己特有的完全混合模式。在 EVS-21 丰田公司的新闻发布会上，动力研发部负责人 Takehisa Yaegashi 先生坦言，他不认为在可见的未来丰田混合电动车中采用

THS 系统会有改变，因为行星齿轮机构足够紧凑、易于批量加工，与电子控制结合后，可实现 CVT 的所有功能。通过与丰田公司的协议，福特公司已被允许将 THS 系统技术用于它的 Escape 混合电动 SUV，2005 年生产 2 万辆。而 2002 年 9 月日产（尼桑）公司与丰田公司签订协议，在 5 年内丰田公司向日产公司提供除发动机外的所有 THS 系统部件，供日产公司生产 10 万辆 Altima Hybrid 2007 中型轿车，日产公司计划 2006 年推向美国市场。

表 1　丰田公司混合电动汽车产品系列（部分）

	Prius II	Crown Royal	Crown Sedan	Estima Passenger car	Alphard Minivan	RX 400h SUV
混合形式	THS II 前轮驱动	轻度混合 后轮驱动	轻度混合 后轮驱动	THS+CVT 四轮驱动	THS 四轮驱动	THS+CVT 四轮驱动
主要尺寸/ mm×mm×mm	4445×1725×1490	4820×1765×1465	4695×1695×1525	4795×1790×1780	4840×1805×1395	4755×1845×1670
额定乘员	5	5	5	7	8	5
空载质量/kg	1250	1660	1480	1860	2000	2000
最高车速(km/h)	171	180	180			200 km/h
加速时间/s (0~100km/h)	10.9					7.6
燃油经济性 km . l^{-1}	35.5	13	13	18. 6	17. 2	12. 34
排放	EU IV	EU IV	EU IV	EU IV	EU IV	EU IV
发动机	1.5 L 76 马力	3.0 L 200 马力	2.0 L 143 马力	2.4 L 131 马力	2.36 L 131 马力	3.31 L 211 马力
电动机	交流同步 50 kW 350 Nm	交流同步 3 kW 56 Nm	交流同步 3 kW 56 Nm	交流同步 前 13 kW 后 18 kW	交流同步 前 13 kW 后 18 kW	交流同步 前 123 kW 后 50 kW
蓄电池	镍氢*28 201.6 V 6.5 Ah	阀控铅酸 36 V 20 Ah	阀控铅酸 36 V 20 Ah	镍氢*30 216 V 6.5 Ah	镍氢*30 216 V 6.5 Ah	镍氢*40 288 V 6.5 Ah
价格/万日圆	215	397	293.5	335	366	

如果说，Insight 是本田公司对世界混合电动汽车市场的问路石，那么混合电动 Civic 就是本田公司对世界混合电动汽车市场布局的真正开始。Civic 是一款紧凑型 5 座家庭用车，本田公司在此款车中坚持了 Insight 中的 IMA 系统，并作了改进。事实上，由于 IMA 系统的简明，世界上还有不少厂家的混合电动轿车也采用了类似的轻度混合结构， 参见表 2。

与 Prius 的 THS 系统相比，IMA 系统的制造成本压力要小得多。如果说丰田公司从 Prius 到 Prius II 改进的重点是降低生产成本，那么本田公司从 Insight 到 Civic Hybrid 改进的重点则是降低系统燃耗，从而进一步降低排放和汽车运行成本。除了对超薄型盘式直流无刷电动机的磁路做出改进，使得其最大再生制动转矩增加大约 30%外的关键措施为采用一汽缸空转系统 CIS 在汽车降速期间降低发动机的摩擦损耗而提高再生制动的回收电能量[3]。

发动机空转时的阻力主要为机械摩擦和泵压阻力两方面。CIS 系统就是在汽车减速而切断发动机供油时使 4 个汽缸中的 3 个的进气门和排气门停止不动，其相应的损耗能量由电动机再生制动利用。采用 CIS 系统后发动机停车时的泵压损耗减少 50%。由于采用这革新后的动力系，Civic Hybrid 达到百千米，油耗 4.9L/100 km，CO2 排放为 116g/km.。

表 2　　国外现有的几种轻度混合电动轿车

	Golf TDI Hybrid 德国大众	Getz Hybrid 韩国现代	Prodigy 美国福特	Xsara Dynactive 法国雪铁龙
混合形式	轻度混合 前轮驱动	轻度混合 +CVT 前轮驱动	轻度混合 后轮驱动	轻度混合 前轮驱动
主要尺寸/ mm×mm×mm	4445×1725 ×1490	4820*1765 *1465	4744*×1755 ×1525	4167×1698 ×1405
额定乘员	5	5	5	5
空载质量/ kg		1660	1082	1100
最高车速(km/h)	190 km/h	161		180
加速时间/s (0~100km/h)	11	12.7		
续驶里程			1060	730
燃油经济性 百千米油耗/L	3.8	5.56	3.42	6. 3
排放	EU IV	EU IV	EU IV	EU IV
发动机/KW	1.4 L TDI 85 kW	1.4 L	1.2 L 55 kW	1.6 L 65 kW
电动机/KW	永磁同步 15	直流无刷 12	交流异步 8	ISAD 5 / 7
蓄电池/V	镍氢 144 0.9 kWh	镍氢 144	镍氢 288 V 4 Ah 1.1 kWh	镍氢 220V 0.6 kWh

继 Insight 和 Civic 之后，本田公司对它的轻度混合驱动系统 IMA 已有了足够的信心来将它推向最主流的车型，5 座全尺寸轿车 Accord 。采用新一代混合动力系统，3 升的 Accord Hybrid 的动力和性能都在当前的 240 马力，2.7 升 V6 经典 Accord 之上。Accord Hybrid 的发动机的整个工作范围内几乎都可得到峰值转矩，从而获得更快的加速、大的通过动力和安静的巡航舒适性。在 Accord Hybrid 中本田进一步发挥了它在 Civic Hybrid 中减小发动机固定损耗的思路，引入了创新的可变汽缸管理技术（VCM），进一步提高了 Accord Hybrid 的效率。在汽车的巡航和减速模式下，使 6 个缸中的 3 个不工作，在效果上将发动机的实际排量降至 1.35 升，与 Civic 的发动机差不多。而这 3 个缸在轻载时不工作不会对整车性能产生影响。

面对十分严格的汽车排放欧 IV 标准和 2008 年起开始执行的温室气体减排规定，各国加大了对汽车排放和燃耗的政策调控力度。混合电动汽车的购买者已从环保人士走向普通用户，混合电动汽车的市场前景越来越好。因此，EVS-21 大会的主题也变昔日的呼吁为号召：Act Now for Sustainable Mobility，自今日做起，从今天奋发。丰田和本田两公司在 Prius II、Civic Hybrid 和 Accord Hybrid 这些混合电动轿车上的持续努力就是高明的汽车商家的 Act Now。从 1997 年至今，他们不受那些争论的干扰，认定了若干年后的市场，一方面踏踏实实抓质量、降成本，突出混合动力的优势，提高混合电动汽车与传统汽车的竞争力；另一方面，宣传市场、创造市场，及时培育市场所需要的产能，在技术、成本和生产规模等多方面拉大与后续商家的距离。

三、动力蓄电池的发展动向

前文已述，丰田公司将蓄电池性能改进与提高当作其混合电动汽车商品化、批量化的极重要的一环。目前的现实是，包括 Prius II、Civic Hybrid 和 Accord Hybrid 等在内的混合电动轿车的商品车上采用的大多是技术比较成熟的镍氢电池。就是在一些城市内行驶的重型混合电动车也有不少也应用镍氢电池。例如欧洲的尼奥普兰混合电动公交大巴，在 EVS-21 会议上展览的奔驰 Sprinter 混合电动厢式送货车。但在 EVS-21 会议上又显露出这一现实后面的值得注意的潜在走向。

根据今后 5 年世界混合电动汽车的市场分析，镍氢电池和锂离子电池的技术进展以及通讯电子产品（手提电脑、手机、相机等）中镍氢电池到锂离子电池的换代速度，观察家推测在电动汽车领域中锂离子电池逐步取代镍氢电池开始于 2008 年[4]。在 EVS-21 会议上发表的数篇论文印证此推测。其中有 3 篇报告应引起我们注意。

一篇是美国能源部关于美国交通系统用先进能源存储技术当前研究规划的综述报告[5]。报告中介绍了美国自由车辆技术规划（FCVT）中的重要组成部分能源存储技术研发的目标、任务和投资。FCVT 规划中对汽车能源存储装置 2010 年达到的技术要求就功率辅助型和主要能源型有所不同。例如功率辅助型的 11 项主要指标中有电池组要在 18 秒内输出 25kW 的脉冲功率，充放电效率不低于 90%，15 年寿命，每组售价不高于 500 美圆（20 美圆/kW）；而主要能源型的 8 项主要指标中有比能量大于 150Wh/kg，工作温度-40～50℃，工作寿命循环大于 1000（80%DOD），售价不高于 150 美圆/kWh。

镍氢电池难于满足该项目的要求。而目前的锂离子电池已经达到了功率辅助型的 11 项主要指标中的 8 个，也已经达到了主要能源型的 8 项主要指标中的 3 个。并具有实现所