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VOLVO

mov'eo
French Automotive Cluster

SAGE
Safe and Green Road Vehicles Europe

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1. EXECUTIVE SUMMARY

1.1. BACKGROUND – PURPOSE AND SCOPE

The aim of this report is to present a mapping and analyse the research and innovation "ecosystem" of nine different automotive research driven clusters in Asia. The regions selected for the analysis are: Beijing, Shanghai and Xi'an in China; Tokyo and Nagoya in Japan; Mumbai/Pune and Bangalore in India, and finally Daejeon and Busan/Ulsan in South Korea. Focus has been on mapping clusters with respect to their ability in the area of Green and Safe road vehicle development.

The work was led by AB Volvo but the collection of data on the different regions presented in this report was provided and prepared jointly by a core team consisting of representatives from MOVEO in France, Continental in Germany, Warsaw University in Poland, and AB Volvo in Sweden. The methodology used to prepare this report is a combination of desk research (literature analysis) based on earlier studies and reports, and interactions with representatives from governmental agencies and private or independent organizations in each region. The primary characterization of each region was done by local experts that had established links with the SAGE project partner organizations. The goal was to provide regional 'insider' information on the R&I ecosystem of the different regions.

The study uses the concept of 'cluster' to describe the character of each regional innovation systems. The cluster concept assumes that there is a geographic concentration of businesses and competence stakeholders in a certain area of technology and this represent the 'ability' of the region in that particular area. A distinction is made between clusters as historical outcome, meaning the actual and complete ecosystem of actors, and 'cluster initiatives', meaning collaboration between a central group of actors that aim to develop the abilities of the actual cluster in a certain technology area.[1] The mapping of a region, therefore, focuses on both the complete cluster and on the cluster initiatives that arise in these regions in the area of green and safe vehicle technology.

1.2. BENCHMARK OF REGIONS

The nine regions in this study were selected for their relevance for research and innovation in the automotive area. The other selection criterion was that established links existed between partners of the SAGE consortium and the different studied regions. One aim of SAGE is to develop collaboration between regions and a choice was made to give priority to the regions with which collaboration could be developed or organized by the partners in the SAGE project

1.2.1. Beijing

The Chinese research and innovation system is complex and to a great extent led by Ministry of Science & Technology (MOST) and China Academy of Science (CAS). In order to strengthen R&I it is common to designate cutting edge technologies and pioneering areas to

[1] Source: Sölvell, Ö (2009) Clusters. Balancing Evolutionary and Constructive Forces. Stockholm: Ivory Tower Publishers; Sölvell, Ö., Lindqvist, G., and C. Ketels (2003) The Cluster Initiative Greenbook.

specific stakeholders to lead the development. Such spearheads may be comprised of geographic regions, industry sectors or specific areas of research. The central government's five-year plans and R&I strategies identify research areas to be prioritized, but even if the objectives of R&I are largely set at the national level, provinces are of great importance with various regional innovation systems having their own initiatives and mechanisms. After China's entry into the World Trade Organization (WTO) in 2001, the development of the automobile market has accelerated quickly. The automotive industry in China is the largest in the world measured by automobile unit production from 2008, where, e.g. in 2011 about 18.5 million vehicles were produced. Of the automobiles produced, almost half were local brands from OEMS such as Great Wall Motor, BYD Auto, FAW and SAIC, many of whom manufacture small, lightweight vehicles suitable for the Chinese consumers and businesses. Those national vendors have been joined in the market by foreign companies, such as VW, Hyundai, Toyota, Ford, GM and Volvo. The approach taken by the global brands has been to establish joint ventures with local vendors. The automobile industry in China has begun to develop also a reputable electrical vehicle sector, supported by both the private and public sector. There is currently a strong political momentum from the Chinese Government to promote low-emission vehicles as well as new-energy vehicles.

The Beijing area has currently a population of 19.6 million people and it is the second largest city by urban population after Shanghai and the economy develops rapidly. Beijing's nominal GDP reached 1.37 trillion RMB in 2010, and increased to 1.6 trillion RMB in 2011. The respective per capita GDP was 78,194 RMB in 2010 and 80,394 RMB (12,447 USD) in 2011, which represents a growth of 8.1% over the previous year. The region is the country's political, cultural, and educational centre, and home to the headquarters for most of China's largest state-owned companies, national research institutions and professional organizations. The Beijing region is home to a great number of colleges and universities, including Peking University and Tsinghua University (two of the National Key Universities). A larger proportion of tertiary-level institutions are concentrated here (at least 70). Beijing is a major transportation hub in the national air, highway, expressway, railway and high-speed rail network.

Beijing Automotive Group (BAIC) is a state-owned enterprise and holding company of several Chinese automobile and machine manufacturers, such as Beijing Automobile Works Co Ltd, etc. Located in Beijing, Beiqi makes Hyundai and Mercedes-branded autos for sale on the Chinese market. 2011 production of more than 1,389,800 vehicles made Beiqi the fifth largest manufacturer in China in 2011. Foton Motor Co.Ltd (Foton) is a state holding listed company that owns 11 brands, including Auman, AUV, Aumark, MP-X, Midi, View, Saga, Ollin, SUP, Tunland and Forland. Foton Motor will have plans to complete 4 production sites of new energy powered automobiles: Miyun Multifunction Auto Workshop, Huairou AUMAN Workshop, Shahe AUV Workshop and Nanhai New Energy Powered Passenger Car Workshop. All the manufacturing units are featured in electric motor driven MIDI car, fully electric sanitation vehicle, and fully electric bus, forming a capacity of 51,000 units / year. A number of smaller and medium sized companies work in electro mobility areas, such as electric drive train technology lithium ion battery manufacturing.

Research is conducted at e.g. the Department of Automotive Engineering in the area of automotive safety, energy conservation, and environmental protection, with a focus on automotive electronics and new power. The Beijing Institute of Technology and the Beijing Jiaotong University conduct research in major engineering disciplines, including several automotive or transportation research areas. Research in green vehicle technology is

conducted at e.g. China Automotive Technology & Research Centre (CATARC), The National Engineering Laboratory for Electric Vehicles (NELEV), the State Key Laboratory of Automotive Safety and Energy at Tsinghua University, the Beijing International Collaboration Base on Sino-US Electric Automobile Technology at Tsinghua University, National Key Laboratory for Vehicle Transmission, BIT, Beijing Municipal Laboratory for Clean Vehicles, BIT.

The supportive policy and funds for projects from the government guide the strong cooperation and networking partnership between universities, research institutions and industry. Every company (from industry) have partnered with a few universities, research institutions and other industry company according to company's needs. The networking partnership is not only limited to the Beijing region, but all over China. Not only existent large firm (Foton) and national research institutions are in the list of important stakeholders for NEV in Beijing, but also many start-ups and new engineering labs (for details see chapter on Beijing region). Policy plays a very important role to attract large firm and new start-up companies to develop and invest in the new energy vehicles and green transportation. Owing to the strong support from both central and local government, Beijing EV technology team has developed their own technology and obtained many patents for its EV technology platform consisting of charging/swapping infrastructure, motor and its controller, battery and drivetrain technology. Many of the technology solutions and patents were developed by universities and industry through common projects.

Compared to European clusters, there are no professional and clear automotive cluster organization in Beijing; however the regional innovation system – as represented by cooperation among the government, academic and research institutions, industry – is regarded to be functional and effective regarding roadmap development for new energy vehicles and green transportation. In China, regional authorities tend to respond to state requirements by also developing local and regional development policy, i.e. the strong position of the state through its large technology development programmes, is counter-balanced by local and regional government initiative and development logic that shapes the actual development paths in the details. Understanding this two-sided development logic is important for understanding the Chinese context.

1.2.2. Shanghai

Shanghai area is centrally located along China's prosperous eastern coastline at the outfall of Yangtze River delta. It has a population of about 18 million people. The city is the commercial and financial centre of mainland China. Thanks to its strategic location Shanghai has become the country's premier sea and river port, the Shanghai harbour is one of the largest in the world. The large amount of goods passing through Shanghai affect the need for transportation, and Shanghai is well developed when it comes to both public transport and road networks. The fact that Shanghai is the largest city in China also affects the need for efficient transport. Due to its location and size Shanghai is identified as an attractive location for manufacturing. Shanghai is one of the main industrial centres of China, e.g. Baosteel which is China's largest steelmaker. The regional government strongly supports research and innovation and Shanghai is acknowledged as a region with good investment climate. It hosts a number of industries such as in electronics and information technology, automobile manufacturing, petrochemicals, steel and biopharmaceutical products.

Vehicle industry in the Shanghai region is primarily represented by SAIC Motor Corporation, which is the largest automotive manufacturing company and it has its headquarters in Shanghai. SAIC products sell under a variety of brand names including those of its joint venture partners, Volkswagen, General Motors and Volvo. In 2010, SAIC produced 3.58 million units and has the largest output of all China-based automaker. Small OEM's are also present, e.g. Shanghai E-drive Co. Ltd. There are also a number of newly established SME in the area of electro mobility: Shanghai H&D EV Battery produce lithium-ion battery packs and battery management system; DLG Power Battery produce lithium-ion battery packs; Shanghai Leibo New Energy has power train of lithium-ion & super capacitor battery; Shanghai Pylon Technology offers series of power cells/packs and energy cells/packs as well as completed power systems; Shanghai Jieneng Automotive Technology offers power and controlling system for hybrid and Electrical vehicle; STK Shanghai Co. offers power and controlling system for hybrid and Electrical vehicle; And finally, the Shanghai Fuel Cell Vehicle Power System, company founded by SAIC & Tongji University, has a role in national fuel cell projects. About two to three percent of sales income of SAIC is from new energy vehicles.

Research capability is primarily centred to the universities of Tongji and Jiaotong, which are the largest universities in the area and that have collaboration with many OEMs, and with other universities and organizations in Europe. The University of Tongji host 860 professors and about 35.000 students and has several centres dedicated to automotive engineering: The Automotive Lab, the National Fuel Cell Vehicle & Drive Line Technology & Research Centre. The Jiaotong University host about 1.900 professors and 43.000 students.

Policy for research in the area of green vehicle technology is being developed. The Shanghai NEV Industry is "R&D centre", "Test centre", "Regulation Centre" & "Assessment centre" for new energy vehicle development field in China. However, China historically has not done much research and development on battery and control system technology, compared to for example Europe. Much of the techniques used to build new energy vehicles rely on import. There is a currently strong push from Chinese government to increase the domestic innovation capability within key technology areas. Shanghai has the ambition of building a NEV industry cluster working within the areas of hybrid techniques, electric vehicles, battery technology development, motor development and control systems development. The district of Jiading is identified as a city for national demonstration of new energy vehicles and it is claimed to be the first international demo city of this kind.

1.2.3. Xi'an

Xi'an is one of the most populous metropolitan areas in inland China with more than 8 million inhabitants. Located in centre China, Xi'an is less developed than Beijing and Shanghai in the economy aspect. The cost of human resource and facility is much cheaper than in Beijing and Shanghai and there are abundant high-quality engineers and researchers in Xi'an thanks to the large number of universities and research institutes. The population of university students in Xi'an is next to only Beijing and Shanghai. Xi'an area has a remarkable capability of aeronautics and aerospace related technologies. Xi'an has become an important base of scientific research, higher education, and especially national defence and hi-tech industries, as well as a centre of finance, science & technology, education, tourism, business and trade, radiating to the Midwest region of North China. The year of 2010 witnesses Xi'an to be designated as one of the first national innovative pilot cities. Xi'an will grow to be a top-tier national innovative city with international influential power from 2015 to 2020. The city is rich in educational and research resources. It has a self-sustained industry system of advanced

manufacturing, electronics, aerospace and aeronautics, automotive industry, etc. There are also large manufacturing factories in Xi'an area.

Automotive industry has developed in recent years. The city has put substantial effort and investment on automobile industry and three automotive corporations are among the top 20 automotive corporations in China. In year 2006/2007, the total production amount was around 106 000 vehicles. After 5 years intensive investment and support from the city, the automotive industry in Xi'an got substantial increase. In year 2009, the production amount was 506 800 vehicles, an increase of 89% compared to the previous year. Three major corporations have become the leaders of the automotive industry in Xi'an, including Shaanxi Automobile Group, BYD, and Shaanxi Fast Auto Drive Group. Shaanxi Automobile Group was on the top 500 enterprises in China in 2003, and is among the 50 most promising automotive companies in China. Its comprehensive capability is ranked as 45 in the list of 500 best mechanical engineering companies in China. Ranked as number one in Shaanxi Province, Shaanxi Automobile Group is the largest manufacturing centre of heavy duty automobiles in Western China. The company is ranked as the 5th in China in terms of the production capability of heavy duty automobiles. Moreover, Volvo Buses used to have a joint venture in Xi'an, which produced high-end large buses. BYD is the primary manufacturer of private cars in Xi'an. The Shaanxi Automobile Group focuses on the design, development, manufacturing and service of commercial vehicles. It is the largest manufacturing enterprise and the unique corporation on new energy commercial vehicles in North-western China. In the field of new energy vehicles, the Group has developed CNG, LNG heavy-duty gas trucks, CNG, LNG bus chassis, flex-fuel, hybrid-electric, full-electric mini-vehicles and low-speed vehicles. The group has active collaboration with the university, such as Xi'an Jiaotong University, and has rich experiences on applying national research funding. The Suda Transport Group is developing full electric vehicles with support of the Henan Province. The Shaanxi Fast Auto Drive Group is the largest specialized production enterprise and export base in China, mainly for heavy-duty auto transmissions, auto gears, forgings and castings. The Shaanxi North Dynamic Co., Ltd is an internal-combustion engine and auto parts manufacturer in China that develops and manufactures DEUTZ 413/513 series air-cooled diesel engine, engine parts, pumps and filters, motorcycle, gasoline generators, mining machinery, and Ti-joints series products.

Chang'an University is a public university emphasizing transportation and vehicle engineering, with 230 professors and about 30 000 students. The School of Automobile is the largest research and education institute dedicated to the automotive engineering in Xi'an. According to the Research Centre on the Evaluation of Chinese Science and Technology, Chang'an University is ranked number 1 among all Chinese universities in the field of Transport Engineering. The Xi'an Jiaotong University is the lead university in Xi'an area, hosting about 30 000 students and 1400 professors and associate professors. It hosts the Institute of Electrical Vehicles and Systems Control, which is dedicated to new energy vehicles. There are also a number of advanced research universities that work in the area of transportation but not primarily on automobile technology. However, these universities represent advanced technology competence useful for advanced vehicle development. Examples are: the North-western Polytechnical University and its Research Centre of Transport Engineering; the Xidian University that a key national university dedicated primarily to electronic engineering and information technology; the Xi'an Institute of Optics and Precision Mechanics of China Academy of Science, which contribute to the Chinese manned space programme; and a number of aerospace research focussed universities (see details is subsequent chapter). The high-technology activities are the most significant

characteristics of the region. High-tech and innovative corporations are concentrated in several special development zones. The total hi-tech industrial output value of these development zones accounts for approximately 90% of the total amount of the whole city.

Policy works through a top-down approach, where governmental agencies have annual and long-term research budget. The agencies will simply choose the best or the closely related universities or institutes to issue the funding. Alternatively, various call for proposals or competitions are organized to receive applications and choose the best candidate. In the bottom-up approach, the universities, institutes, and companies may write proposals to public funding agencies or private venture capitalist. There are also much spontaneous collaboration between the companies and the universities, where dedicated projects are funded by both universities and the companies to solve jointly interested problems. Financing of innovative projects are mostly the responsibility of government, e.g. Xi'an Pioneering Park Development Centre (Xi'an High-tech Productivity Centre). The large corporations may also share the responsibility depending on the potential of the projects. The most important technological development area in Xi'an will still be manufacturing and aeronautics and aerospace. Automotive industry shares a lot of common technology basis with these strong fields and has a tremendous market in China and the world. Hence it is also a prioritized development area in the Xi'an area.

1.2.4. Tokyo

The following two sections develop the results from the studied regions in Japan. Japan is the fourth largest economy after USA, China and India in purchasing power parity comparison[2]. It is a world leader in several sectors such as automotive, electronics and generally in production, especially in production quality. The industry sector in Japan plays a leading role in research and innovation and major industrial stakeholder conduct their research in-house, to a large extent. With regard to the academic side Japan is also strong with more than 750 universities of which almost 600 are privately operated. Japan is a world leading manufacturer of automobiles and it is home to many large automotive companies, such as e.g. Toyota, Honda, Daihatsu, Nissan, Suzuki, Mazda, Mitsubishi, Subaru, Isuzu, Kawasaki, Yamaha, and Mitsuoka. The country is the third largest vehicle manufacturer in the world after China and USA. Less than 1% of automotive RTD in Japan is publicly funded. Most of the public funds are issued by the Ministry of Economy, Trade & Industry (METI) and supplied through the New Energy and Industrial Technology Development Organization (NEDO). Private investment contributes to a majority of automotive RTD spend.

The Tokyo region hosts more than 25% of the Japanese population. The capital is the decision centre of the country and home of the major companies' headquarters. Tokyo has the largest metropolitan economy in the world based on the industrial and services sector: finance, tourism, automobile, electronic, chemical, heavy industries. Greater Tokyo's Railway Network is the world's largest in terms of both daily passengers with a number of daily trips of over 40 million (20 million different passengers). Tokyo and its suburbs is the main financial, industrial and commercial centre in Japan. Industrial activities are much diversified:

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[2] Source: http://en.wikipedia.org/wiki/Purchasing_power_parity

food, textiles and clothing, heavy industry, high technology (electronics, optics, cameras, etc.), mechanical engineering, chemicals, etc. - are concentrated along the shores of Tokyo Bay forming a huge industrial area. This complex provides a fifth of the national industrial output value. Heavy industry is predominant: oil refinery, steel industry. The city hosts 47 of the Fortune Global 500 companies, the highest amount of any city in the world. Tokyo has the largest city economy in the world and is one of three command centres along with New York City and London.

Automotive industry in the Tokyo region is, however, not very strong. The Tokyo region is generally speaking not suitable as manufacturing site due to the high real estate cost. The automotive industry is concentrated to other regions, to Aichi (Toyota), Kyushu (Fukuoka-Kitakyūshū), Hiroshima (Mazda) Kanagawa (Nissan), Saitama (Honda) and Shizuoka (Suzuki). Two main companies are located in the Tokyo region: Nissan motor and Hino. There are historically two kinds of automotive companies in Japan. The first type is that a big company has created an automotive company such as Nissan and Mitsubishi Motors, the latter established from the Mitsubishi Heavy Industry. The second type is that a local company has created an automotive company, such as Toyota, Honda, Suzuki and Mazda. Another particularity of Japanese automotive industry is that big car manufacturers don't work together on main subjects and even don't share suppliers. Each of them has its own ecosystem of factories, research centres and suppliers. The collaboration between Japanese car manufacturers is found especially in the public research sector where JARI is an intermediary for non-competitive knowledge sharing on specific themes (electric, hybrid, fuel cell). Some universities, in particular Waseda, Hiroshima, and Kyoto, are working on automotive topics but the main part of R&D is done internally by each manufacturer.

Research universities and public laboratories in the region are considered excellent, though automotive research is not primarily conducted here. The University of Tokyo and its Institute of Industrial Sciences has about 160 research laboratories and is the oldest national university in Japan. The Waseda University is a private Japanese university with more than 53.000 students. The university host the Waseda Mobility Lab, which covers R&D activities over the entire chain of electric vehicle technology, ranging from technology components to system solutions in vehicles. However, since there is no large industrial concentration in the automotive sector such as compared to other Japanese regions, notably Aichi, Kyushu and Hiroshima, etc., research is not regionally linked to the industry. In Japan the private automotive sector plays the leading role in the R&D and innovation and private investment contributes to majority of automotive R&D spend. Furthermore, the innovation climate of vertical organization doesn't facilitate large interaction between innovation agents.

Policy for cluster development within the Japanese government is established through "framework plans" for the development of science and technology by combining academic research policy with industrial development policy. University spending on scientific research has been increasing rapidly and university-industry partnerships as well as regional research interactions have been growing steadily for the last few years. It is however difficult to identify any real automotive cluster development in the Tokyo region, and there are no cluster organization or particular regional cluster policy. Triple-helix-type of actors is not very active. Cooperation is mainly bilateral, through a direct link between one OEM and a university, or between one OEM and its suppliers. With its key competences in electronics and IT, the Greater Tokyo area has indeed indisputable possible strengths for the future development of Safe and Green road vehicles.

1.2.5. Nagoya

Nagoya is the second region in Japan studied in this report. Nagoya is the largest city in the Chūbu region and also one of Japan's major ports. The Nagoya area accounts for approximately 1% of the global GDP and about 10% of gross regional product in Japan, which gives the region a strong economical ability. The Greater Nagoya region has good research infrastructure both at academia and industry level. Since this cluster contributes to 10% of Japan's GDP, it supports research for the development of new vehicles with new technology. Automotive, aerospace and ceramic industries are the main industries in the Nagoya region. Many automotive players have their presence in the Nagoya region. Lexus has it's headquarter in this region. Mitsubishi Motors have R&D headquarters in Okazaki located in the suburbs of the Nagoya. It also hosts automotive suppliers like DENSO, Aisin Seiki, Toyota Industries, Toyota Boshoku, Aerospace-related firms operating in Nagoya include Boeing, Pratt & Whitney, Mitsubishi Heavy Industries, Bodycote, Kawasaki Heavy Industries and Fuji Heavy Industries. Toyota, Mitsubishi and DENSO are examples of strong automotive players active in the region. The large global companies provide strong in-house research facilities and dominate the research and innovation agenda in the region. Cross cultural interaction and more of triple helix structures could possibly bring more flexibility into the system.

The automobile industry is a large part of the industrial presence in Nagoya. Greater Nagoya boasts one of the world's largest clusters of automotive companies. World-renowned and technically advanced automakers such as Toyota, Honda, Suzuki, Mitsubishi, Volkswagen, and General Motors have headquarters and major manufacturing operations in the region. About 44% of all automobiles produced in Japan come from Greater Nagoya area. This means that also automobile supplier industry cluster in the region. In the Nagoya region, there are many companies located firstly as the textile industry that now have been converted to be automotive component suppliers. Today, the automotive industry is crowded in this area and in order to reduce the associated risk, Toyota has decided to construct new manufacturing plants in Kyushu and Tohoku (Northern part of Honshu), further achieving the low operating costs. Japanese manufacturers have been early to develop electric drive-line vehicle for the market and also have a track-record in development of light-weight vehicle concepts.

There are 22 universities in the area, many of which have engineering disciplines. For example Nagoya University that host about 16.000 students and Nagoya Institute of Technology with about 5000 students have major contribution to science and technology development. The GreMo (Green Mobility Collaborative Research Centre) is one example that cluster collaboration is now being applied. GreMo is supported by local and national authorities, university and industry and gathers inter-disciplinary researchers of the Nagoya University within for example materials, ITS and Human Factors. The members of the Green Mobility Collaborative Research Centre have a track record in research in the area of green mobility in automotive mechatronics, energy and environmental studies, next generation batteries and ITS. The Toyohashi University of Technology that has about 2200 students and operate a Research Centre for Future Vehicle City with research in fuel cells, traffic safety and electric vehicles. The National Institute of Advanced Industrial Science and Technology (AIST) and Nagoya Institute of Technology cooperate with academia and business on research projects and development of resources for industry

Regional policy is linked to Greater Nagoya Initiative Centre, which was established as a joint organization of national government, local governments, industries and academia. It was

created to promote foreign direct investment and alliance between overseas and Japanese companies. In cooperation with affiliated organizations, GNIC provides "one-stop" services to overseas corporations interested in starting or expanding business into Greater Nagoya. Such complimentary services for overseas businesses include providing information on the region, research, public information and advertising, invitations, matching up with appropriate corporations and assistance for business start-ups. Public policy for cluster development origin from the national agency, METI (The Ministry of Economy, Trade and Industry) that has adopted a new policy of cluster development to reinforce the dynamics of industrial networks involving universities, businesses and governments in clusters. Other national policy of relevance to the automotive industry in the region is e.g. JARI (Japan Automobile Research Institution), which is an independent and non-profit research organization that promotes pioneering research to understand the future, and diffuse of next-generation vehicles. The automotive cluster has shown a proactive trend in the area of alternate fuels[3] especially in the area of hybrids and plug in hybrids. Automotive players in the area are actively involved in the development of new energy vehicles.

1.2.6. Mumbai/Pune

The Indian economy is the fourth largest economy in the world on the basis of Purchasing Power Parity (PPP). It is one of the most attractive destinations for business and investment opportunities due to huge manpower base, diversified natural resources and strong macro-economic fundamentals. Also, the process of economic reforms initiated since 1991 has been providing an investor-friendly environment through a liberalized policy framework spanning the whole economy. The Indian economy is estimated to grow by 6.9 % in 2011-12. It has grown at the rate of 8.4% in each of the two preceding years. As a developing nation India places a large emphasis on higher education. It has a large number of Colleges and Universities along with other specialized Institutions, Training centres and other colleges that offer a wide variety of courses to choose from. In terms of vehicle manufacturing India is today one of the world's largest manufacturers of tractors and two wheelers. The country is the fifth largest manufacturer of commercial vehicles and the sixth largest passenger car manufacturer in the world. The automotive industry has direct and indirect employment of more than 13.1 million people. Especially after the liberalization policy started in 1991, most global automotive manufacturers entered India and established local manufacturing bases through joint ventures with local partners. Foreign manufacturers and local players formed multiple clusters attracting component suppliers all over India. The 2006–2016 National Automobile Mission Plan set out the goal to establish India as the destination of choice in the world for design and manufacturing of automobiles and auto components. The Plan target is to reach output levels of USD 145 billion, which would account for more than 10% of the national GDP and provide additional employment to 25 million people by 2016. Tata Motors Limited is India's largest automobile company. The company is the world's fourth largest truck manufacturer, and the world's second largest bus manufacturer. Tata Motors has also emerged as an international automobile company, through subsidiaries and associate companies operated in the UK, South Korea, Thailand and Spain. Among them, Jaguar and Land Rover, two iconic British brands, were acquired in 2008. Besides local OEMs like

[3] Alternative fuels in the sense Non-conventional or advanced fuels, are any materials or substances that can be used as fuels, other than conventional fuels. Conventional fuels include: *fossil fuels* (petroleum (oil), coal, propane, and natural gas) http://en.wikipedia.org/wiki/Alternative_fuel

TATA Motors Ltd, Mahindra Groups, Ashok Leyland Ltd and Bajaj Auto Ltd, there are many Joint Ventures with foreign OEMs, like BMW India pvt Ltd, Volvo India pvt ltd, Ford India pvt Ltd, Hyundai motor India, etc.

The Mumbai/Pune region is represented by two cities in Maharashtra, which is the second most populous state and the third largest by area in India. Maharashtra is the richest state in India, contributing 15% to the country's industrial output and 13.3% to its GDP (2006–2007 figures). Mumbai, the capital city of the state, is India's largest city and the financial capital of the nation. Maharashtra is renowned for the production of three-wheelers, jeeps, commercial vehicles and cars, synthetic fibres, cold rolled products and industrial alcohol. Small-scale industries have also come up in a big way in the state. Maharashtra has set up software parks in Pune, Mumbai, Navi Mumbai, Nagpur and Nasik, Aurangabad. Now Maharashtra is the second largest exporter of software and is responsible for 30% of the country's total software exports.

The automotive industry in the Mumbai/Pune region hosts many of the main competences; many automotive OEMs and suppliers are present in the area. Companies like General Motors, Volkswagen, Skoda, Mahindra, Tata Motors, Mercedes Benz, Land Rover, Fiat and Force Motors are settled in the area. The focus is mainly on manufacturing. The economic development is very strong and the human resource is ample and relatively cheap. However there is a lack of skilled and trained workforce and in general the productivity is relatively low. Nevertheless, the size of this West Indian automobile hub is comparable to the size of clusters in European regions, while, however, in terms of new development in the area of safe and green road transport it has currently a smaller role due to the small size of automotive R&D activities. The focus on frugal technology may create new products and potentially a reverse technology transfer of small affordable energy efficient vehicles.

The educational system is large. Maharashtra area has good human resource development in terms of educational institutions, an impressing 301 engineering/diploma colleges, 616 industrial training institutes, and more than 24 universities with a turnout of 160,000 engineers and technicians every year. The region hosts some of the country’s best academic institutions. In Engineering there are: Indian Institute of Technology (IIT-B), Mumbai, Visvesvaraya National Institute of Technology (VNIT), Veermata Jijabai Technological Institute (VJTI), Sardar Patel College of Engineering, University Department of Chemical Technology, College of Engineering Pune (COEP), Fergusson College, Pune, Government College of Engineering Aurangabad, Government College of Engineering Amravati, Government College of Engineering Karad, Walchand College of Engineering, Sangli (WCES), Shri Guru Gobind Singhji Institute of Engineering and Technology Nanded (SGGSIE&T). The Automotive Research Association of India (ARAI) is a central actor for research activities aimed at the vehicle and automotive sector.

The main policies of the region originate in the corporate sector. There is in fact very little policymaking influencing the automotive industry directly that originate from the state or the central government. The policy that exists aims to achieve higher and sustainable economic growth with emphasis on balanced regional development and employment generation through greater private and public investment in industrial and infrastructure development. The corruption level is high, and transparency, trust, and responsibility are on a lower level. However, compared to other big clusters the West Indian Hub is still competitive for all leading points. The automotive cluster is mainly organized through Automotive Research Association of India (ARAI) and Auto Cluster, which give the opportunity to collaborate with

an existing Cluster Organization that include the many major stakeholders from automotive and non-automotive sector. However the absorption of innovation and change is going quite slow.

1.2.7. Bangalore/Chennai

Chennai and Bangalore have developed into one of the leading auto clusters in India. In spite of geographical proximity, Bangalore and Chennai show different types of patterns in terms of their development. Chennai and Bangalore are 300 km apart but as they are in different states of India Tamil Nadu and Karnataka, respectively. The culture, language, socio-economic trends are different in these states. Karnataka is one of the high economic growth states in India with an expected GSDP (Gross State Domestic Product) growth of 8.2% in the fiscal year 2010-2011. Tamil Nadu is the highest industrialized state in India. Automobile, textile, heavy industries, leather are major industries in Tamil Nadu.

The automotive clusters in Bangalore and the Chennai automotive cluster are one of the older clusters in India. Many Indian automotive OEMs started their operations in India and are now supported by the presence of international 'Tier I' suppliers (e.g. Continental, Delphi, Bosch) that produce for the global vehicle industry and that manufacture in India also for premium brands in Europe. The cluster has a general good presence of both Tier I and Tier II suppliers to the automotive industry. Chennai and Bangalore are also among the fastest growing cities in India. The regional distribution of OEMs is Chennai (Ashok Layland, Ford, BMW, Renault Nissan, Nissan, Mitsubishi Motors, TVS, and Mahindra) and in Bangalore (Volvo, General motors, Mercedez Benz, Toyota, Tata Marco polo) and in Hyderabad (Hundai). For example Mahindra Reva electric vehicles located in Bangalore is responsible for one of the largest deployed fleet of electric vehicles with 3 000 vehicles sold globally. In construction is a new plant with capacity of 30 000 vehicles per annum.

The university system provide Bangalore and Chennai with a pool of educated resources from many engineering collages in the region, such as from the premium institutes like Indian institute of sciences, Bangalore, Indian Institute of Technology, Madras and Indian Institute of management in Bangalore. These institutes are also proactive to have industry collaboration and they promote research and entrepreneurship. Bangalore being the 'IT hub' of India has many multi-national companies complementing the automotive industry for services and software development. It is very evident that many global companies like Bosch, Continental, Delphi, General Motors, and Mercedes Benz have their development centre in this cluster.

The cluster policy is facing challenges like mismatch between the growth rate of cities and infrastructure development, corruption, etc. The Indian market is primarily driven by cost and consumer demand, hence acceptance to new energy vehicles as a business case will largely depend on government support. Local state government is supporting the growth of the industry through providing infrastructure, skilled manpower development and financial support to the new initiatives. Central government provides the umbrella support though various industry specific policies like Auto policy. Recently launched policies for electric vehicles will boost the initiative towards the electric and hybrid vehicle development (National Electric Vehicle Mission Policy). Government has announced the 4B$ national electric vehicle mission policy under which India has put a target of 6 million electric vehicles in 2020. It is expected to boost the use of electric and hybrid vehicles in India. It predominantly will have huge effect on the market for two wheelers.

1.2.8. Daejeon

The studied regions in South Korea are Daejeon and Busan/Ulsan. South Korea has a population of about 49 million, predominantly living in urban areas. Key technologies driving the economy are automobile, ship building, semiconductor, ICT, telecom and manufacturing. Korea has one of the highest rates of spending on R&D in the world, of which most is performed by private firms. It also has a highly educated labour force with a strong interest in science and technology. Korean RTD expenditures are above 4% of the national GDP, well above Europe and the OECD average. Korea is among the most technologically advanced and digitally connected countries in the world and a recognized market leader in electronics, mobile communication, shipbuilding and automotive with well-known multinational conglomerates (chaebols) like Samsung, LG and Hyundai. Taking advantage of the recovery in external demand, particularly from Asian countries including China, it has now returned to the path of sustained growth (+4%) and has the ambition to develop new sources of growth in the sustainable development sectors: renewable energy, electric vehicles, and public transport. The country also has an automotive sector that is an important part of the economy. With production of 4.3 million vehicles in 2010, South Korea is the world's fifth largest automaker, after China, Japan, the US and Germany. Contributing to 10% of national production, the automotive sector remains a pillar of the Korean economy. While its initial operations were merely the assembling of parts imported from Japan and the United States, Korea is today among the most advanced automobile-producing countries in the world. In the late 90's, Korean OEMs initiated a major restructuring that enabled them to gain competitiveness and quality. The Korean automobile industry is characterized by the pre-eminence of Hyundai-Kia, the fourth largest car manufacturer in the world in 2010 (representing 74% of the Korean automotive production). The other producers are GM Korea and RSM (Renault Samsung Motors).

The Daejeon region was selected due to several reasons. Most of the industry research centres as well as the national labs are located in Daejeon. A research complex called "Innopolis-Daedeok Research Complex" has been established in the early 90's to accelerate cooperation between academia and industry and has been showing tremendous progress in the last decade. In addition to this, public funding agencies are placed within the area that enables networking though e.g. different conferences and consortiums. Compared to the Busan cluster, where Hyundai Motors is the main player, Daejeon is represented by new technology driving force, whereas Busan is the automotive industry leader in the existing technology and manufacturing.

Research in the Daejeon region hosts a range of high-technology activities but not specifically aimed at automotive industry development. New vehicle and energy technology however demand such competence. KAIST (formerly the Korea Advanced Institute of Science and Technology) was established as the nation's first research oriented science and engineering institution. KAIST is the foremost centre of strategic research and development (R&D) projects. The University helped to pioneer the establishment of competitive research oriented graduate school programs in Korea. There are currently 6 colleges, 2 schools, 21 departments, 3 divisions, 6 professional graduate schools and 10 interdisciplinary programs. Researchers at KAIST have developed an electric transport system (called Online Electric Vehicle, OLEV) where the vehicles get their power needs from cables underneath the surface of the road via non-contact magnetic charging. There are also several institutes. KARI (Korea Aerospace Research Institute) is a research centre located in the Daedeok research complex. KARI

performs basic and applied studies in aerospace technology as well as government-delegated tasks and support policy development. In addition, KARI supports industries and transfers technology. When working with the industry, KARI performs joint utilization of testing facilities and equipment as well as training scientists and engineers. Various types of research are being held at KARI from aircraft, helicopter to aerospace and rockets. KATECH (Korea Automotive Technology Institute) is located in Cheonan close to Daejeon. It was established in 1990 to innovative technology development for the Korean automotive industry. Distribution of automotive technology for the industry as well as contribution to the technological achievement and competitiveness of the industry is the main aim for its existence. Since its foundation, KATECH has been setting the standard in the Korean automotive industry and expanded its facility dramatically. The research and development categories at KATECH are: Green car powertrain, intelligent vehicle technology, Materials and components and Corporation support and reliability.

Public policy for renewal in the industry and development of new technologies is mainly initiated by the government. Request for proposals are usually placed with no restriction for the application. However, recently proposals that include collaboration among industry and academia have been encouraged. Based on the recent announcement by the S. Korean government, it was evident that the majority of the budget was dedicated to increase the technology in the areas of ground transportation as well as in processing technologies. Aside from the public funding process, small and medium sized companies are supported in working with OEMs. The majority of the small and medium enterprises do not have the ability for characterization or prototyping due to initial high cost investment. South Korea has no petroleum on its natural resource list meaning no oil production within the country. Since 20 percent of the country's energy consumption accounts by the transportation sector, "Low Carbon-Green Growth" has been stated as the technology motto since October 2009 by President Lee Myung-Bak. Development of Electric Vehicles has become one of the major national initiatives to align with the global environmental regulations as well as a measure against high fuel prices. With the national goal set to focus on the EVs, relevant ministries and government agencies were deeply involved in EV development plans. Industry and academia along with research institutes set the main goal for EVs. MKE (Ministry of Knowledge Economy) is responsible for the EV expansion and has launched the "Green Car Forum" with government specialist, university experts and different business sectors to establish meaningful strategies in developing and commercializing the environmentally-friendly vehicle.

1.2.9. Busan/Ulsan

Busan is South Korea's second largest city after Seoul, with a population of around 3.7 million. Ulsan is South Korea's seventh largest city with a population of over 1.1 million. It is located in the Southeast of the country, neighbouring Busan to the south and facing Gyeongju to the north and the Sea of Japan to the east.

The Busan/Ulsan region is home of the Korean automotive industry. The key industrial actors that have their plants in this strategic location are the car-makers (Hyundai and Renault-Samsung-Motors) and the automotive industry suppliers (Mobis, Posco and SK). Busan is South Korea's second largest metropolis after Seoul, having a large port. Busan is also the economic and logistic hub of Korea's Southeast Economic Belt, where Korea's leading industries are located. A total of 50% of national output in shipbuilding, 90% of ship parts, 45% of automobile manufacturing and 40% of general machinery is produced in the Busan

region. Ulsan is considered to be de-facto "capital of Korean industries" and it is responsible for about 13% of the nation's industrial production and exports, representing a value of over USD 55 billion.

The Ulsan automotive cluster consist of around 120 small- to mid-size parts suppliers, mainly those in the fields of automobile interior parts, car body, and chassis (Small companies with less than 50 employees each account for approximately 50%). There is a lack of independent enterprises of middle standing because of a high level of dependence on one car company (Hyundai Motor). Hyundai Motor's Central Research Institute is located in the metropolitan area. As a result, its partner companies also moved to the area. The city forms South Korea's largest industrial cluster, connecting the automobile, shipbuilding, and petrochemical industries

The University and institute sector in the Ulsan area is the University of Ulsan and the Ulsan National Institute of Science and Technology (UNIST). Relevant research institutes are the Research Institute of Industrial Science & Technology (RIST) and the Ulsan Techno park site. An Automotive Parts Innovation Centre is located at the technology park. The Busan Techno Park has centres focussing on automotive parts technology and next generation heat engines.

The Busan-Ulsan cluster can be regarded as traditional industrial cluster; the activities are focused on production, rarely on R&D. The automotive activities in the Ulsan region are mainly focused on Hyundai while the automotive activities in Busan region mainly are focused on RSM. Main focus of research for both areas are e.g. new processes, new materials, vehicle electrification and ITS. The industrial clusters are supported by the national agency KICOX but also by Busan Metropolitan City and Ulsan Metropolitan City. They are mostly focused on production; the R&D activities being mainly located in the north of the country. The authoritarian model of Korean society, the competition between the 2 carmakers and the supremacy of Hyundai do not encourage the development of 'open' research driven clusters. However we remark interesting practices through the 2 techno parks (Busan Techno park and Ulsan Techno park). They provide support for new technology development and shared infrastructures. Owned by public authorities, they facilitate cooperation among the industry, academies, research institutes and the government. They are also open to collaboration with European partners.

1.3. CONCLUSIONS

Despite large differences between the selected regions in terms of size, local specificities, economic conditions, and historical path of development, it is possible to discern some trends and tentative conclusions.

The automotive regions in China are governed by the Chinese research and innovation system which is complex and even if the goals for research and innovation to a great extent are set on a national level, provinces are of great importance with various regional innovation systems with their own initiatives and mechanisms. The general picture shows that research is driven top-down and strongly connected to the centrally decided five-year plan. The boundaries between public authorities and the private sector are not as clear as in Europe. A clear cluster structure is difficult to identify since much depends on strong competition between actors both regarding research and innovation and in the Chinese society as a whole.

The region around Shanghai is known worldwide for its automotive industry. The city is a demonstration city for New Energy Vehicles and is well known for competences within e.g. batteries, motors, power electronics and charging systems. There is a strong focus on R&I which is also true for the Beijing region. Beijing as capital city is the decision center of the country and there is a strong supportive policy for Safe and Green Vehicles.

The Indian economy is the fourth largest economy in the world (PPP) and is one of the most attractive destinations for business and investment opportunities due to huge manpower base, diversified natural resources and strong macro-economic fundamentals. However the present R&D ecosystem is still developing. As a developing nation India places a large emphasis on higher education and the government promotes innovation, but not yet in a clear way with a structured framework and an integrated ecosystem. The regional cluster in India shows large growth due to general economic growth and the educational system can be regarded as competitive. The resulting capability in innovation in the automotive sector, however, is developing. The extent of industry academia partnership is also limited and availability of funds is an issue.

In Japan the clusters are dominated by the presence of large automotive companies as Toyota and Mitsubishi. Research and innovation is to a great extent conducted in-house within the major companies and the Japanese government's funding to industry is very small (only 5%). There is no clear triple helix structure within the clusters that were investigated but some approaches to establish collaborative research have been started and are strongly supported by current policies. GreMo (Green Mobility Collaborative Research Center) in Nagoya is one example that cluster collaboration is now being applied. GreMo is supported by local and national authorities, university and industry and gathers inter-disciplinary researchers of the Nagoya University within for example materials, ITS and Human Factors.

In general South Korea does not have a clear culture of cluster cooperation. Cooperation between big companies is rare and the link between university and industry with respect to research is weak and mostly based on direct company-university relations. The Korean automotive industry has so far been following technology development focusing on fast market introduction. In order to become a global technology leader policy makers and industry have initiated new activities to strengthen the countries own innovative capabilities. To strengthen collaborative R&D is one of these initiatives including cluster cooperation between universities and industry. There is also a strong focus to become fourth largest producer of electric vehicles by 2020. Of the two regions described in this report Daejeon stands out as a very innovative R&D focused region compared to Busan/Ulsan which is more manufacturing oriented, as the home of Korean automotive industry. Daejeon is a very dynamic area with for example KAIST and Innopolis (KAIST has direct relations with the main Korean industries & Innopolis Daedeok represents 15% of National R&D spending) as main actors. Areas where there region is prominent are for example connectivity, energy efficiency and vehicle automation.

The Asian regions are substantially larger than the European, but are they substantially more potent and 'stronger' with respect to innovation? A tentative conclusion from this study, with respect to the 'size' of automotive clusters and their 'R&D capability', is that this relationship may be different from what is usually assumed. The 'size' of research-based knowledge networks in automotive technology in a region seems not to be linear to the size of regions or the size of countries. The number of top experts within a field in a small country may in fact be in the same magnitude of order as in larger countries. The impressing number of new

universities in automotive regions for example in China does not automatically mean that there exists substantially more expertise in China in very specific automotive technology research areas. For the less knowledge-intensive domains of knowledge-based cluster, however, these differences in size between regions and nations become more important. Large automotive regions are naturally larger in terms of the size of the firms and the number of people working in engineering and manufacturing in these firms. This naturally represents potential differences in terms of capability in large-scale manufacturing and for the ability to test and verify incremental development steps in vehicle product development. A group of say 10 000 vehicle engineers will probably be able to develop a more solid product than do 1 000 or 100 engineers. Still, there are numerous examples in the history of the automobile where it is not the number of engineers or the size of firms that explain innovation or transfer of advanced technology knowledge into useful and attractive solutions. Also smaller clusters have proven to be able to manufacture advanced vehicle products and to be 'innovative' and provide competitive levels of manufacturing and product quality. What this means for smart specialisation of clusters, regional innovative capacity, and collaboration strategy with Asian clusters is still an open question.

The main purpose of WP7 within SAGE is to select 3-4 clusters and establish a collaboration strategy within the focus areas of green and safe road transport. For this selection two parameters are particularly important: The clusters need to display a strong R&D capability and preferably also have established links or contacts to partners in the SAGE regions.
The tentative conclusion for a next step is that the regions of Beijing, Shanghai, Nagoya and Daejeon seem to be particularly interesting, based on the criteria's mentioned above.

INTRODUCTION

1.4. BACKGROUND

The SAGE project (Safe and Green road vehicles) is a project under the European Regions of Knowledge program framework of FP7. The science and technology scope of SAGE are safety for drivers, passengers and other road users as well as greening of road transport. This is achieved partly by conducting thorough analysis of regional clusters of all SAGE partners. To be able to learn from best practice from regions outside the partnership of SAGE, the project also maps automotive clusters/regions outside of Europe. This deliverable presents the mapping of international automotive clusters.
The work was led by AB Volvo but the collection of data on the different regions presented was provided and made jointly by a core team consisting of representatives from MOVEO in France, Continental in Germany, Warsaw University in Poland, and AB Volvo in Sweden.

The study uses the concept of 'cluster' to describe the character of each regional innovation systems. The cluster concept assumes that there is a geographic concentration of businesses and competence stakeholders in a certain area of technology and this represent the 'ability' of the region in that particular area. A distinction is made between clusters as historical outcome, meaning the actual and complete ecosystem of actors, and 'cluster initiatives', meaning collaboration between a central group of actors that aim to develop the abilities of the actual cluster in a certain technology area. The mapping of a region, therefore, focuses on both to describe the complete cluster and on the cluster initiatives that arise in these regions in the area of green and safe vehicle technology.

The starting point is that innovation and renewal to a large and possibly increasing extent takes place in collaboration and interaction between actors within local or regional clusters. In this industry, academia and policy-making bodies intertwine. The central role for the clusters is then to act as innovation environments. Increasing globalization concerning both production and trade patterns creates a growing need for international networks. Cutting-edge technology as well as production is traded globally and also "knowledge production" begins to occur in the increasingly global networks.

When talking about national and regional strategies for growth, research and innovation; clusters are an important component in many countries. It is also high on the agenda for international organizations like the European Union. Innovation –and research strategies have high visibility and the link between market and research has been clarified. In this report focus is put on research driven automotive clusters with the ambition of linking enterprise, academy and knowledge organizations together as a common denominator.

1.5. OBJECTIVES

Work package 7 focus on International collaboration. The objectives of the international work package are to identify and benchmark research driven automotive clusters with a focus of safe and green in different regions in Asia. This report makes an attempt to characterize/map the existing research and innovation landscape, by providing a map of the primary actors and organizations within the areas of green and safe.
Nine regions across four countries in Asia are chosen for analysis. The regions selected and described, in terms of capabilities, target markets, R&I activities, collaboration models,

important stakeholders etc. are: Beijing, Shanghai and Xi'an in China; Tokyo and Nagoya in Japan; Mumbai/Pune and Bangalore in India and Daejeon and Busan/Ulsan regions in South Korea (See Figure 1).

Figure 1: Regions chosen for analysis

The nine regions were selected for their relevance for R&I in the automotive area. The other selection criterion was that established links existed between partners of the SAGE consortium and the different studied regions. One aim of SAGE is to develop collaboration between regions and a choice was made to give priority to the regions with which collaboration could be developed or organized by the partners in the SAGE project.

The overall purpose of the benchmark of international clusters are to analyse how other countries/regions link market and research together and to learn more about the processes that control cluster organization in different places.

Results of the mapping of regions (regional reports) provide input to an analysis of regional strengths, weaknesses, opportunities and threats (SWOT) which will be the basis for the International Collaboration Strategy and the common SAGE Joint Action Plan.

The regional/cluster analysis of the status and prospects for safe and green road vehicle technology in selected regions were carried out between December 2011 and September 2012. The purpose of the report is thus both to provide a characterization of the regional capacity as well as current and planned activities with respect to the two competence areas. Another aim of this report is to provide information on the regional eco system for research and innovation so that comparison can be made between the clusters. A detailed and thorough analysis of how the described clusters operate in their cultural and national/regional context is, for obvious reasons, not provided in this report. To be able to provide that type of analysis more detailed studies are needed.

1.6. METHODOLOGY

The methodology used to prepare this report is a combination of desk research (literature analysis) of earlier studies and reports and interactions with representatives from governmental agencies, private industries and independent organizations.

The regions selected for analysis in this study were selected because of their importance for research and innovation in the automotive area. Another important aspect in the selection of regions was their connection to the partners in the SAGE consortium.

To be able to describe the regional innovation systems in the regions chosen for the benchmark, local representatives within the partner organizations of SAGE at site, provide the characterizations. Some information is also provided by desk-top research from a distance. The fact that information about each region is provided by different sources, together with the fact that the regions mapped are very different in themselves makes the descriptions of the eco systems for research and innovation differ both in form and content.

Due to the wide scope of this report and the large amount of data treated a deep and detailed analysis about how each cluster really works is not presented. To be able to provide that type of analysis more detailed studies are needed.

The main categories mapped are:

- General and automotive data about each country
- Description of the regional eco system of research and innovation - Actors, competences and activities
- Technology competence and economic ability of the region/cluster
- Cluster organization and management
- Unless otherwise indicated in the text, information presented is taken from each organizations homepage.

Process description

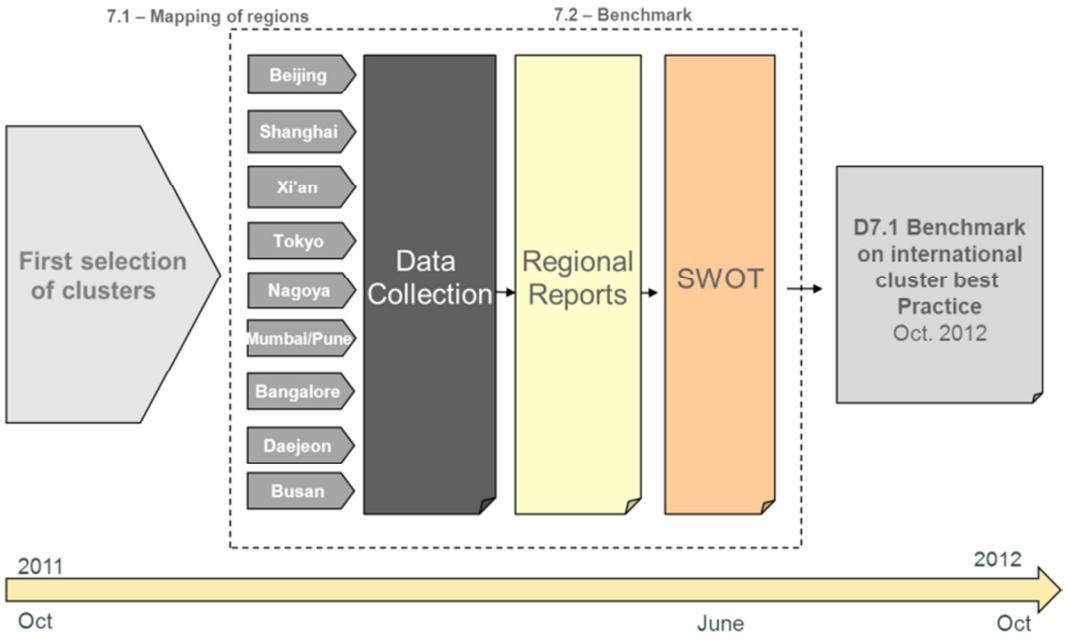

Figure 2 Process description

Disclaimer

This document presents both qualitative and quantitative data from different sources. Due to the large amount of data constantly changing during the duration of the project, it is not possible to thoroughly validate all details. The SAGE project partners cannot guarantee that the data presented is either complete or correct in all detail.

2. CHINA

2.1. GENERAL INTRODUCTION

This chapter provides an overview of China in order to give a sense of the history, economy, cluster policies and automotive history. A more detailed characterization will be presented in the benchmark of the three regions chosen in the SAGE project; Beijing, Shanghai and Xi'an.

2.1.1. History[4]

The People's Republic of China (referred hereafter as China) is one of the biggest countries in the world and stretches some 5,026 kilometres across the East Asian landmass, bordering the East China Sea, Korea Bay, Yellow Sea, and South China Sea, between North Korea and Vietnam.

China has the world's longest, uninterrupted recorded history and is thereby considered as one of the oldest civilizations of the world. In the late 1800s and early 1900s the Republic of China was created out of several major rebellions (including the Boxer Rebellion), which eventually led to Xinhai revolution in 1911 that created the Republic of China.

Since 1949 and the Chinese Civil War, China is ruled under a communist policy by the Communist Party of China, which sets the rules of the country in a centralized way. This also has an impact on the way research and development is planned and carried out.

2.1.2. Economy

Since the late 1970s China has moved from a closed, centrally planned economical system to a more market-oriented one that plays a major global role. In 2010 China became the world's largest exporter. China's unique long and rapid economic growth has largely been based on low labour costs. Historically the Chinese industry has been built on manufacturing and assembly but in the recently decided twelfth Five-

China at a glance:

Population: 1, 34 billion (47% live in urban areas)

Median Age: 35,9 years

Area: 9 600 000 km² (fourth largest country in the world)

GDP: 11 trillion Yan (forst quarter 2012)

Key industrial technologies: Mining and ore processing, iron, steel, aluminum, and other metals, coal; machine building; armaments; textiles and apparel; petroleum; cement; chemicals; fertilizers; consumer products, including footwear, toys, and electronics; food processing; transportation equipment, including automobiles, rail cars and locomotives, ships, and aircraft; telecommunications equipment, commercial space launch vehicles and satellites.

[4] Source: http://en.wikipedia.org/wiki/China

Year Plan the Government's ambition is to "change the development model," which means trying to move up the value chain - from production of simple goods towards advanced manufacturing and innovation. Few countries have increased their expenditure on R&D as rapidly as China has for the past few years. The massive infusion of resources has been driven by a combination of motives: cultivating universities with global recognition, increasing the visibility of Chinese research, strengthening linkages between academic environments and industry, supporting high value-added industry, and strengthening China's international prestige[5].

A possible problem for the coming years is that China is now one of the most rapidly aging countries in the world due to their population control policy. Deterioration in the environment - notably air pollution, soil erosion, and the steady fall of the water table - is another long-term problem. Economic development has progressed further in coastal provinces than in the interior, and by 2011 more than 250 million migrant workers and their dependents had relocated to urban areas to find work.

2.1.3. Cluster policy

China places a huge emphasis on knowledge transfer and cooperation with other countries in research and innovation, which means there is a strong demand from China for international cooperation. This enables creation of important "science diplomacy" needed to start cooperation, but to be successful it is also required to find areas where there are common interests and where both sides can benefit from a partnership.

The Chinese research and innovation system is complex and to a great extent led by Ministry of Science & Technology (MOST) and China Academy of Science (CAS). In order to strengthen R & I it is common to designate cutting edge technologies and pioneering areas to lead the development. Such spearheads may be comprised of geographic regions, industry sectors or specific areas of research. Central government's five-year plans and R & I strategies identifies research areas to be prioritized, but even if the objectives of R & I is largely set at the national level, provinces are of great importance with various regional innovation systems with their own initiatives and mechanisms, e.g. the Guangdong Province. A clear cluster structure is difficult to see since much depends on strong competition between actors both regarding research and innovation and in the Chinese society as a whole[6].

In China there is not as sharp distinction between public and private industry as in the West. Even private companies undertake, or are given commitments, in fulfilment of the overall objectives from the government, for example concerning the development of new energy vehicles.

The volume of research collaboration between EU countries and China seem to have a volume of the organizational presence in China since special "Science Offices" have a tendency to be set up by companies already established in the area. Only a few EU countries have a nationally determined approach to working. In other words, it is not the strategies

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[5] Source: Benner,M., Liu, L., Schwaag Serger, S (2012) Head in the clouds and feet on the ground: Research priority setting in China. Science and Public Policy Advance Access

[6] Source: Jeding, C., Wikström. M., (2011)Forskningspolitik och internationalisering – Kina. Landrapport Tillväxtanalys

which drive the presence and activity, but perhaps rather the reverse. The agreements that the EU countries have with China on research cooperation includes, as a rule, designated areas of focus. These overlap in the relatively high level between countries. Areas of focus are often formulated on the basis of problems or challenges, rather than on academic disciplines.

Within the European Commission 7th framework program (2007-2013) China is the third most important external partner after USA and Russia.

2.1.4. Automotive sector

After China's entry into the World Trade Organization (WTO) in 2001, the development of the automobile market accelerated quickly. The automotive industry in China has been the largest in the world measured by automobile unit production since 2008. In the year of 2011, a total of 18.5 million vehicles were produced. Of the automobiles produced, almost half were local brands. The local Chinese market is addressed mostly by local OEMs, such as Great Wall Motor, BYD Auto, FAW, and SAIC, many of whom manufacture small, lightweight vehicles suitable for the Chinese consumers and businesses. Those vendors have in recent years been joined on the Chinese market by foreign companies, such as Toyota, Ford, GM and Volvo. The approach taken by the global brands has been to establish joint ventures with local vendors.

The automobile industry in China has begun to develop a large and reputable electrical vehicle sector, supported by both the private and the public sector. There is a strong political momentum from the Chinese Government to promote low-emission vehicles as well as new-energy vehicles.

2.1.5. National research bodies

The Chinese Academy of Sciences (CAS)

CAS was founded in Beijing on 1 November 1949, one month after the founding of the People's Republic of China. CAS was mandated as the key force of the new China's scientific research system, undertaking missions of defining scientific research orientations, restructuring its research institutions, encouraging and helping overseas Chinese scientists to return home, training and properly allocating professionals, outlining strategies for the nation's future scientific and technological development while contributing to the national economic and social development.

CAS is now targeting at the national strategic needs and frontiers of science, striving to accomplish world-class science and to make fundamental and forward-looking contributions to national economic construction, national security and social sustainable development by strengthening original scientific innovation in the area of innovation of key technologies and system integration. CAS is nation's highest academic institution in natural sciences; it consists of the Academic Divisions and various subordinate institutions. The life-long honor of CAS member is the highest academic title set up in science and technology in China. It has now 694 CAS members in total (including members, emeritus members and foreign members)

There are six academic divisions, functioning as the national scientific think-tank, providing advisory and appraisal services on issues stemming from the national economy, social development and S&T progress. There are 12 branch offices, 117 institutes with legal entity, more than 100 national key laboratories and national engineering research centres, and about

1,000 field stations throughout the country. Its staff even surpassed 50,000; there are totally 328 members either of the CAS or of the Chinese Academy of engineering working in CAS institutes, and 703 recipients of the National Outstanding Youth Funds in the academy. Through the talent introduction programs, the CAS has recruited 1,416 excellent young talents in the past few years. Among those employed in the whole Academy's innovative posts and positions, 77% have Doctor's and Master's degrees, and researchers who are younger than 45 account for 79.1% of the total.

The CAS Award for International Cooperation in Science and Technology was set up in 2007. Fellowships and cooperative programs were established, including the Einstein Professorship, the Visiting Professorship for Senior International Scientists, Programs for International Partnership Groups, Fellowships for Young International Scientists and TWAS-CAS Fellowships for Visiting Scholars, Postgraduate and Postdoctoral

In 2009, Science & Technology in China: A Roadmap to 2050 series has outlined major scientific issues and critical technical problems in China's modernization process, and made suggestions on how to resolve them, ensuring the contribution of science and technology in realizing China's modernization goals by 2050.

China Automotive Technology &Research Centre (CATARC)

CATARC was established in 1985 response to the need of the state for the management of auto industry and upon the approval of the China National Science and Technology Commission. It is affiliated to State-owned Assets Supervision and. Administration (SASAC). The Headquarter of CATARC locates in Tianjing, 120 km far from Beijing and it takes 30-40 minutes by train. There are 2051 employees working in CATARC with 848 technical professionals, including 43 professor-level senior engineers, and 51 doctors, 232 senior engineers.

Assets and land area has totally 2600 million and 625.33 thousand square meters (including 450 ㎡ the New Base). The new base covers an area of about 300,000㎡ construction area. This construction project will last 3 years from May 2009 to 2012 with the total investment of RMB 1.25billion.

CATARC assists the government in such activities as auto standard and technical regulation formulating, product certification testing, quality system certification, industry planning and policy research, information service and common technology research has built up certain scale and competence through setting up testing labs and research departments and attracting a group of technical talents. The Headquarter includes following institutes:

- Auto Standardization Research Institute
- Auto Testing Research Institute (Tianjin Auto Testing Centre)
- Auto Industry Planning, Design and Research Institute
- Auto Technical Information Research Institute
- Quality System Certification Centre (CAQC)
- C-NCAP Management Centre
- Auto Engineering Research Institute (AERI)
- Post-doctoral Research Centre

The National Engineering Laboratory for Electric Vehicles (NELEV)

NELEV is an outgrowth of Beijing Institute of Technology (BIT) Electric Vehicle Centre of Engineering and Technology, which is the first organization doing researches on EVs since the end of 1950s when an electric vehicle was imported from the Soviet Union. NELEV are since 1992, engaged in EV research organized by Ministry of Industry and Information Technology P. R.,

Under the strong support from Ministry of Science and Technology, Ministry of Industry and Information Technology, General Armament Department and Beijing Municipal Government, it accumulated rich experiences in the research, industrialization and operation of EVs during the eighth, ninth, tenth and eleventh Five-Year-Plans. NELEV has solid research foundation in researches of electric drive motors and is authorized as the National Test Base for EV Drive Motors. The laboratory has so far completed 19 kinds of EVs, including pure/hybrid electric sightseeing buses, pure electric low-floor buses, fuel cell vehicles and pure electric cars, etc. seven of which are listed in the National Bulletin of Automobiles. NELEV has developed key elements and accessories for EVs with independent intellectual property, among which there are after flow enhanced magnetism PM motor and its controller, Automatic Mechanical Transmission (AMT) and a standard battery pack solution for a fast battery exchange system.

During the 2008 Beijing Olympic Games, NELEV fulfilled Chinese government's promise to carry out the unprecedented project of zero-emission electric buses and realized the nation's ultimate goal of providing 24-hour sound EV service, which received positive response at home and abroad, Achievements made in the Olympic EV project have also been fully applied in the 2010 Shanghai Expo and 2010 Guangzhou Asian Games. NELEV developed the charge station for bus line 121 in Beijing and built the first complete battery charging & swapping station for Olympic electric buses in the world. NELEV has been the recipient of many prizes, such as two second prizes of National Award for Technological Invention, one second prize of National Prize for Progress in Science and Technology, one first prize for Progress in Science and Technology issued by Ministry of Education, P. R. China.

Foton - National Level Energy Savings and Emissions Reduction Lab

Foton began its construction on March 29, 2006 and was established on August 28, 2007 and covers a surface area of 13,380m2, provides indoor and road tests, engine tests and component tests by NVH tester, with the core missions of automobile energy savings and emissions reduction and by building a product test platform of high-end emissions analysis, environment simulation and comprehensive performance testing, the Lab introduces advanced core testing equipment and runs under ISO/IEC 17025 to forge a broad, deep and high-level testing system and serve better new automobile product development.

2.2. BEIJING REGION

The following description of the regional research and innovation eco system within green and safe is provided by a local contact in Beijing, familiar with the region.

2.2.1. Background information

Beijing is one of the most populous cities in the world and China's second largest city by urban population after Shanghai. It is the country's political, cultural, and educational centre. Beijing is home to the headquarters for most of China's largest state-owned companies and it is a major transportation hub in the national highway, expressway, railway and high-speed rail network. Beijing's Capital International Airport is the second busiest in the world by passenger traffic.

Beijing at a glance:

- **Population:** 19,6 million inhabitants
- **Area:** 16 801km²
- **GRDP:** USD$247.7 billion (2011)
- **Major industry:** communication equipment, computer & others, automobile, smelting and processing of ferrous metals, petroleum processing and coke products, machinery for special purposes, food and beverage, electric equipment and machinery

Transport infrastructure

Beijing is one of the largest hubs in China's railway network. Eight conventional rail lines radiate from Beijing to: Shanghai, Guangzhou, Kowloon, Harbin, Baotou, Qinhuangdao, Chengde and Yuanping, Shanxi. In addition, Beijing has two high-speed rail lines: the Beijing-Shanghai High-Speed Railway, which opened in 2011, and the Beijing-Tianjin Intercity Railway, which opened in 2008. Beijing is connected by road links to all parts of China as part of the National Trunk Road Network. Nine expressways of China serve Beijing, as do eleven China National Highways. Beijing's urban transport is dependent upon the six "ring roads" that concentrically surround the city, with the Forbidden City area marked as the geographical centre for the ring roads.

Beijing Capital International Airport is currently the second busiest airport in the world and the busiest in Asia. After renovations for the 2008 Olympics, the airport now boasts three terminals, with Terminal 3 being one of the largest in the world. Most domestic and nearly all international flights arrive at and depart from Capital Airport. Other airports in the city include Liangxiang, Nanyuan, Xijiao, Shahe and Badaling. These airports are primarily for military use and are less well known to the public. Nanyuan serves as the hub for only one passenger airline. A second international airport, to be called Beijing Daxing International Airport, is currently being built in Daxing District, and is expected to be open by 2017.

The Beijing Subway in the public transportation system opened in 1971, and had only two lines until Line 13 began operating in 2002. Since then, the subway has expanded to fourteen lines. There are nearly 700 bus and trolleybus routes, including three bus rapid transit routes. All public transport can be accessed with the Yikatong card, which uses radio frequencies scanned at subway stations and on public transit buses. In May 2010, Beijing's municipal

government announced plans to add 21 subway lines by 2020. The plan calls for 30 subway lines and 450 stations in Beijing, reaching 1,050 Kilometres in length. When fully implemented, residents within the region encompassed by the Fourth Ring Road will be able to walk to a station in 10 to 15 minutes. The suburbs will be connected by new radial lines.

Competitiveness and economy

Beijing is the country's political, cultural, and educational centre and home to the headquarters for most of China's largest state-owned companies. It hosts a large number of colleges and universities, including Peking University and Tsinghua University (two of the National Key Universities). Owing to Beijing's status as the political and cultural capital of China, a larger proportion of tertiary-level institutions are concentrated here than in any other city in China (at least 70).

Beijing is increasingly becoming known for its innovative entrepreneurs and high-growth start-up companies. This culture is backed by a large community of both Chinese and foreign venture capital firms. Though Shanghai is seen as the economic centre of China, this is typically based on the numerous large corporations based there, rather than for being a centre for entrepreneurship. The Beijing central business district (CBD) has been identified as the city's new central business district, and is home to a variety of corporate regional headquarters, shopping precincts, and high-end housing. Beijing Financial Street is a traditional financial centre. In 2010, Beijing's nominal GDP reached 1.37 trillion RMB. Its per capita GDP was 78,194 RMB. In 2011, Beijing's nominal GDP reached 1.6 trillion RMB. Its per capita GDP was 80,394 RMB (12,447 USD), a growth of 8.1% over the previous year. The Zhongguancun Science Park had total revenues of 1.93 trillion Yuan ($304.58 billion)7 in 2011. The zone's value-added output reached 306.26 billion Yuan in 2011, a year-on-year increase of 17.1 %, which contributed 24 % of Beijing's economic growth, or 19.1 % of the city's GDP.

Organizations and laboratories

- Chinese Central Government and Ministries
- China Electro technical Society
- China Association of Automobile Manufacturers (CAAM)
- Chinese Association for Science and Technology
- The Chinese Academy of Sciences (CAS)
- Society of Automotive Engineers of China (SAE-China)
- China Automotive Technology &Research Centre (CATARC) (located in Tianjin)
- China Electronics Technology Group Corporation—18th Institute (CETC18)
- The National Engineering Laboratory for Electric Vehicles (NELEV), Beijing Institute of Technology (BIT)
- State Key Laboratory of Automotive Safety and Energy, Tsinghua University
- Beijing Engineering Laboratory for E-Business Technologies, Tsinghua University

[7] Source: http://en.zgc.gov.cn/2012-03/16/content_14851654.htm

- Beijing International Collaboration Base on Sino-US Electric Automobile Technology, Tsinghua University
- National Key Laboratory for Vehicle Transmission, BIT
- National Key Laboratory for Mechatronic Engineering and Control, BIT
- Beijing Municipal Laboratory for Clean Vehicles, BIT

Societal issues

- Smog;
- Dust storms in spring
- Poor water quality;
- High cost of the basic services such as electricity and natural gas;
- Traffic jam;
- To reduce air pollution, a number of major industries have been ordered to reduce emissions or leave the city. Beijing Capital Steel, once one of the city's largest employers and its single biggest polluter, has been relocating most of its operations to Tangshan, in nearby Hebei Province
- Problems of urbanization, such as heavy traffic, poor air quality, the loss of historic neighbourhoods, and a significant influx of migrants from various regions of the country, especially rural areas.

2.2.2. Regional innovation system

This chapter describes the various players of the cluster and regional systems to support innovation.

Industry

Foton Motor Co.,Ltd (Foton).[8] Foton was founded on August 28, 1996, a trans-regional, trans-industry and trans-ownership state holding listed company. The headquartered is in Changping District, Beijing, existing assets of nearly 30 billion Yuan and Foton has nearly 40,000 employees. Foton is a large enterprise group that takes Beijing as the management centre, owns vehicle and parts departments in nine provinces, municipalities and autonomous regions including Beijing, Tianjin, Shandong, Hebei, Hunan, Hubei, Liaoning, Guangdong and Xinjiang, and has R & D branches distributed in countries and regions such as China, Japan, Germany and Taiwan. In 2010, Foton's brand value stood at 38.872 billion Yuan, ranking first in the commercial vehicle field. In 2010, Foton sold more than 680,000 units, maintaining the lead among global commercial vehicle manufacturers.

Foton owns 11 brands, including Auman, AUV, Aumark, MP-X, Midi, View, Saga, Ollin, SUP, Tunland and Forland, Till the middle of the 12th Five-year Plan, Foton Motor will complete 4 production bases of new energy powered automobiles: Miyun Multifunction Auto Workshop, Huairou AUMAN Workshop, Shahe AUV Workshop and Nanhai New Energy Powered Passenger Car Workshop, all the workshops are featured in electric motor driven

[8] Source: http://www.fotonmotors.ae/index.ASP

MIDI car, pure electric motor driven sanitation vehicle, and pure electric motor driven bus, forming a capacity of 51,000 units / year. Foton built its R&D headquarter in Beijing as its management centre to control the company's research and development (product plan, organizational plan, business plan, capability construction, system construction, etc.). The Vehicle Engineering Institute responsible for product definition, vehicle engineer, body system, chassis system, power system matching, electric system, research and development management, etc. The second level R&D centres mainly working with Vehicle Engineering Institute on structure development, product improvement and in charge of technical support for production department, Foton established R&D centres in Germany and Japan to develop vehicles and electric control systems and promote cutting-edge technology research and new technology application, Foton holds 1215 patents covering all brands of vehicle products and breaking through several technical obstacles, of these patents, there are 193 patents of innovation, 677 patents of utility model and 345 patents of industrial design (Nov 2011). Foton also has a National Level Energy Savings and Emissions Reduction Lab described in chapter 2.2.2

CITIC GUOAN Mengguli (MGL).[9] MGL was founded in April 2000, mainly engaged in the research, development and production of new composite metal oxide materials and high energy density lithium-ion secondary batteries. MGL is the largest and the most advanced enterprise in the fields of new material and new energy technology. It holds a large ground in Zhongguancun Science Park, including mill buildings and laboratories. MGL has a suite of advanced analytical instruments and laboratory equipment. The yearly production capacity of lithium-ion battery cathode materials is more than 2500 tons. It produces 2000 tons of LiCoO2, 500 tons of LiMn2O4 and large quantity of LiCo0.2Ni0.8O2 per year. It can produce batteries of 20 million Ah every year. MGL has undertaken lots of key scientific and technological subjects of the Nation, the local governments as well as the ministries. With the significant researching results obtained one National Sci-Tech Progress Award (II) and two Beijing Sci-Tech Awards (I). In the field of energy materials, obtained more than 30 patents from home and abroad for the manufacturing technique of LiCoO2, LiMn2O4 and LiCo0.2Ni0.8O2. MGL is listed in the New and Hi-Tech Enterprises and certificated to the standards of ISO9001:2000, CE and UL. It drew up national standards of LiCoO2 and industrial standards of LiMn2O4. At present, MGL has established close cooperative relationship with Peking University, other colleges, universities and research institute in China, such as Chinese Academy of Science, and formed strategic partnership with many research centres of large enterprise groups in technologically developed countries. Over nearly ten years' efforts, MGL Research Institute has successfully developed into a first-class comprehensive international research centre, focusing on the research and development of energy-saving and environmentally friendly high-end technologies.

BIT Huachuang EV Company.[10] BIT Huachuang was established on the basis of NELEV in July 2010 in order to accelerate the industrialization of EV products. The main task of Huachuang is to develop and test EVs and some key components for EVs, supply the advanced electric bus technology platform and its key components, and provide the

[9] Source: http://www.diytrade.com/china/manufacturer/702482/main/CITIC_GUOAN_MENGGULI_POWER_SCIENCE_TECHNOLOGY_CO_LTD.html

[10] Source: http://bitev.org/en/context.php?id=40

technology solution on new energy vehicles etc. The company has 4 professors and 8 associate professors and senior engineers, as well as some famous experts in the fields of vehicle engineering, vehicle electronics, power electronics, mechanical manufacturing and automatic control, etc., employs many engineers and technical workers with rich experiences. Huachuand has established its own engineering base in Huairou (a county of Beijing), Huachuang EV Company has strong engineering capabilities to develop a series of electric vehicles, with key components such as vehicle controllers, integrated electric drivetrain systems and other key components of top-quality electric cars and to provide strong technology support for automotive industries in the field of alternative energy vehicles.

Dianba Technology Company.[11] Dianba is a fresh company but very successful company which committed to the infrastructure for electric vehicles. Dianba has three location offices and manufacturers facilities that locate in Beijing, Shanghai and Guangzhou plus a branch in Los Angles of the United Stated. The company has about 200 employees who are the research and technology core resource. The solution Of Dianba is to setup E-Station by charging and swapping the battery and optimizes energy efficient for smart grid. Dianba's system has been applied for 4 e-stations in China before 2011: Beijing Beitucheng station for 50-100 electric buses since Beijing Olympic Games in 2008, Shanghai station for 120 buses since Shanghai Expro, Guangzhou station for 26 buses in 2010 and Ningxia station in 2011. Dianba has partnership team to work out together to develop EVs infrastructures and green transportation technology: Beijing Institute of Technology, China State Grid, Beijing Jiaotong University, Beijing Automobile, BAIC Group, SAIC Motor, MGL etc.

Broad-Ocean Motor EV Co., Ltd. Broad-Ocean Motor EV, established in May 2009, located in Beijing Zhongguancun Yongfeng, is the outstanding solution provider for EV motors and driving system. It is a subsidiary of Zhongshan Broad-Ocean Motor Co., Ltd which is a professional and successful private enterprise, listed at Shenzhen Stock Exchange Centre in 2008. Broad-Ocean Motor EV focuses on the vast market space and strong demand for the motors that are applied on new energy automobiles, in today's energy conservation society. Cooperated with Beijing Institute of Technology, FOTON, BAIC, HIGER, Wuzhoulong, Changan Motors etc, Broad-Ocean has equipped with the most advanced technology in the field of researching and developing PMSM and its driving system for EV.

Miscellaneous manufacturers

- BAIC New Energy Automotive Co.,Ltd. Founded in Nov.2009, electric passenger car producer
- Jing-Jin Electric Technologies (Beijing) Co., Ltd. Electric Motor provider;
- Time Hig-Tech Co.Ltd. founded in 2001, Electric Motor provider;
- Pride-Power Co.Ltd. founded in 2009 Battery and battery pack provider;
- Beijing Qianqin Technology registered in 2003, provide electric motor ;
- Tianjin Lishen Battery Joint-Stock Co., Ltd. established on December 25th, 1997. Its products include six series, cylindrical battery, prismatic battery, polymer battery, power battery, photovoltaic, ultra capacitor.

[11] Source: http://www.e-bus.com.cn/eng/news/news_154.html

Universities and research institutes

Tsinghua University.[12] The university was established in 1911, originally under the name "Tsinghua Xuetang". Now it has 389.4 hectare campus area and 204.4 hectare building area. The university has 16 schools and 56 departments in science, engineering, humanities, law, medicine, history, philosophy, economics, management, education and art. Tsinghua has 3133 faculties, among them 40 Members of Chinese Academy of Sciences, 34 Members of Chinese Academy of Engineering, and 1242 Postdoctoral Researchers. The university also has 39,470 registered students, including 15,050 undergraduates (including 1314 international students), 15,984 post-graduates (including 1011 international students), 8436 Doctor Candidates (including 175 international students). The scientific and technological research and projects are mainly supported by (the special projects and funds of) the national science and technology programs, which provide over 1000 million Yuan for more than 1000 projects (covering 50% of the research contracts) every year for the university

The Department of Automotive Engineering (DAE). DAE undertakes scientific research on 3 themes: automotive safety, energy conservation, and environmental protection, with a focus on 2 technological revolutions - automotive electronics and new power. The department has considerately strengthened the construction of the academic communication platform, such as academic saloon, not only to promote the academic communication among the teachers in the department, but also to provide opportunities for the teachers to communicate with many top experts from home and abroad. DAE has accomplished 19 national scientific and technical key projects, 62 National '863' Programs, 4 National '973' Programs, 44 projects sponsored by Natural Science Fund of China, 64 National Defence Projects, 63 provincial and ministerial vital projects, and 156 international cooperation projects.

Beijing Institute of Technology (BIT).[13] BIT was founded in Yan'an in 1940, a national key University under China Project 211 & 985 and under the administration of Ministry of Information and Industry. The institute has 17 academic schools and 43 research institutes (or research centres) in the area of Aerospace, Mechatronic, Mechanical Engineering, Software, Optoelectronics, Automation, Computer Science & Technology, Material Science & Engineering , Information and Electronics, Chemical Engineering and Environment, Life Science, Management and Economics, Humanities and Social Sciences, Law, Design and Arts, Language , Design and Arts. BIT has 4 First-Grade National Key Disciplines, 5 Second-Grade National Key Disciplines, 3 National (in Cultivation) Key Disciplines and 20 Ministerial Key Disciplines. BIT has 3431 staff in total, including 1931 academic and 1500 general. Among 1931 academics, there are 9 Academicians of Chinese Academy of Science, 19 Chang Jiang Scholars, over 400 Professors, over 900 Associate professors, 12 State Experts with outstanding contributions and 251 Recipients of special subsidies from the central government. 43991 students enrolled in total, including 14006 undergraduates, 5617 post graduates, 2544 Ph.D candidates, 242 International students and 22077 Distance program and vocational students.

[12] Source: http://www.tsinghua.edu.cn/publish/then/
[13] Source: http://english.bit.edu.cn/

Beijing Jiaotong University (BJTU).[14] BJTU was established in late Qing Dynasty and can be traced back to 1896. BJTU is a national key University under China Project 211 & 985, under the direct administration of the Ministry of Education and jointly sponsored by the Ministry of Education and the Ministry of Railways. BJTU has 12 academic faculties, which are the School of Electronic and Information Engineering, the School of Computer and Information Technology, the School of Economics and Management, the School of Traffic and Transportation, the School of Civil Engineering and Architecture, the School of Mechanical, Electronic and Control Engineering, the School of Electrical Engineering and Electrical Power Studies, the School of Science, the School of Humanities and Social Sciences, the School of Foreign Languages and Mass Communication, the School of Software Engineering, and the Department of Architecture and Art Design. The university has 8 national key disciplines, which are Traffic and Transportation Planning and Management, Traffic Information Engineering and Control, Communication and Information Processing, Information and Signal Processing, Industrial Economics, Road and Railway Engineering, Transportation Tools Application Engineering, and Bridge and Tunnel Engineering. BJTU has 2,842 full-time employees, among which 1,668 are faculty members, 286 full professors and 588 associate professors, 3 academicians from CAS and 7 from CAE, 4 National Renowned Teachers, 4 members of State Council Academic Evaluation Committee, 3 National 973 Chief Scientists, 6 Changjiang Scholar and Chair Professors, 7 National Hundred-Thousand Talent Project members, and 181 experts receiving government special stipends, etc. The university has fostered more than 100,000 talents for the nation. Now there are 13,971 undergraduate students, 5,433 masters and 2,094 doctoral students, and 8,767 continuing education students. The fixed assets of research facilities have reached 523 million RMB. 1 national key lab, 2 national engineering labs, 1 national engineering research centre, 3 national certification labs, 3 MOE key labs, 4 MOE engineering research centres, 4 municipal key labs, China Integrated Transportation Research Centre and China Centre for Industrial Economic Security Research. The library of BJTU has a collection of 1.39 million volumes of print books, 0.33 million volumes of digital books, 1.95 million volumes from network resources, and several databases.

Governmental and other public organizations

- Beijing Municipal Commission of Development & Reform (BMCDR)
- Beijing Municipal Science & Technology Commission (BMSTC);
- Beijing Municipal Commission of Economy and Information Technology (BMCRIT);
- Beijing Municipal Bureau of Environmental Protection (BMBEP);
- Beijing Municipal Commission of Urban Planning (BMCUP);
- Beijing Municipal Commission of Transport (BMCT);
- Finance Bureau of Beijing (FBB);

Professional organizations, e.g. chambers of commerce

- China Electro technical Society: Organize international academic conference and exchange; establish connection and cooperation with international professional organization.

[14] Source: http://en.njtu.edu.cn/index.htm

- China Association of Automobile Manufacturers (CAAM): its main functions are policy research, information service, self-discipline in the trade, international communication and exhibition service.
- Society of Automotive Engineers of China (SAE-China): Promoting scientific & technical progress of China automotive industry; Fostering the growth of automotive scientific & technical professionals; Promoting technical exchange among automotive industries at home and abroad; Spreading and popularizing the knowledge of automotive science & technology; Building a close-knit community for automotive engineers
- Beijing Federation of Industrial Economics: conduct research and investigation on the strategy of industrial development, the industrial economic restructuring, the progress of industrial technology, the organization and management of industry, the trend and dynamics of industrial development at home and abroad; and to raise suggestions to the government for decision-making.
- Beijing Federation of Industry & Commerce: Strengthen construction of trade associations and chambers of commerce, and serve the development of non-public enterprises; Participate in coordination of labour relations, and promote social harmony and stability; Reflect the interests and appeals of enterprises and personages of the non-public sector, and safeguard their legitimate rights and interests.
- Beijing Automotive Trade Association
- Beijing Enterprise Confederation (BEC)
- Beijing Energy Conservation Comprehensive Utilization
- Beijing Intellectual Property
- Beijing Federation of New Energy Vehicles (NEV) Industry

Business incubators

The business incubators listed below are service for any high-tech and innovation business including Green transportation.

- Beijing Hi-tech Innovation Service Centre: to build a platform for international development of global small and medium-sized enterprises (SMEs) in hi-tech fields such as ICT, Bio-pharmaceutics, energy saving and green technology, etc.
- Hi-tech International Business Incubator Co., Ltd. (HTIBI): offers reliable, high-quality alternative to in-house resources for international business development, market development, distribution strategies and channel development on an international scale.
- Beijing Zhongguancun International Incubator Inc.: provide incubation services in accordance with government guidance combined with enterprise operation to overseas returned students who want to start technology-based small and medium enterprises
- Peking University Incubator: gathering high-end industries, improving innovation ability and promoting economic development; increasing the regional independent innovation ability; accelerating the formation of innovation system with Zhongguancun characteristic that regards enterprise as the body, market as the guidance and combines production, teaching and research together.
- Beijing IBI (The Pioneering Service Centre for Zhongguancun Fengtai Science Park): established five innovation service systems: venture training, information network, lab-equipment sharing, investing & financing and intermediary service.

Science Parks

- Zhongguancun Science Park, including Haidian Science Park,Fengtai Science Park, Changping Park Zone, Electronics City, Yizhuang Park Zone, Desheng Park Zone, Jianxiang Science Park, Tongzhou Science Park, Shijingshan Science Park, Yonghe Science Park and Daxing Pharmaceuticals-related Research Base 11 Science Parks in different locations, involved in different High-Tech research fields, industries and modern manufactures. Each science park has their individual management institution.
- Beijing University National University Science Park: nurturing and gathering a puzzle of potential enterprises concerning the fields of biological medicine, electronic information, energy conservation and environmental protection and cultural innovation.

Technology Transfer Agencies

Local level

- Zhongguancun Science Park;
- Beijing Municipal Science & Technology Commission(BMSTC);
- Beijing Science & Technology Cooperation Centre (BSTCC)
- Beijing Capital Sci & Tech Group Corp.
- Beijing Hi-Tech Transfer Service Centre
- Beijing Hi-Tech Business Innovation Service Centre
- Fundraising

State level:

- National High Tech R&D Development Program (National 863 Program): promoting the applied research and accelerating high-tech development
- National Basic Research Program of China (National 973 Program): focuses on comprehensive and multi-disciplinary basic research
- National Natural Science Foundation: a funding agency under the State Council for the management of the National Natural Science Fund which mainly supports basic research in universities and research institutes
- Talents Funds: include the National Science Fund for Distinguished Young Scholars, National Science Fund for Distinguished Young Scholars of foreign citizenship, Joint Research Fund for Overseas Chinese Young Scholars, Joint Research Fund for Hong Kong and Macao Young Scholars and Fund for Creative Research Groups. The objective of the first four funds is to encourage and attract overseas young Chinese scholars (under 45 years old) to return and carry out research in China. The Science Fund for Creative Research Groups finances the research groups led by outstanding Chinese scientists in specific basic research fields with great innovative potential
- International Cooperation and funding: includes four project categories and three special funds: joint research projects, international (regional) academic conferences held abroad, international academic conferences held in China, major joint research projects, fund for Chinese scholars abroad returning for short-period of work or lecture, joint fund between NSFC and the Research Grant Council of Hong Kong and fund for international cooperation and exchange of State key laboratories.

Municipal Level:

- Beijing NEV Project funds from Beijing Municipal Government (BMSTC, BMCDR, BMCRIT) for R&D, demonstration and industrialization

Regular events that can act as collectors of stakeholders, e.g. Fairs, networking events…

- The 15th China Beijing International High-Tech Expo (every year since 1998)
- Beijing International Auto Show (every two years in Beijing)
- "Low-carbon Park Development" Forum held in Zhongguancun
- China New Energy Auto Expo (2012 CIAPE will be held during 26-28 Oct.2012)
- The 8th Beijing International Pure Electric Vehicles, Hybrid Electric Vehicles and Clean Energy Vehicles & Auto Parts Exhibition 2012 (Every year)

Innovation platforms

- Zhongguancun National Engineering Technology Innovation Base
- Beijing NEV Industrial Base
- Beijing Industrial Base for NEV Design & Manufacturing
- Beijing Daxing Technology Park for NEV
- Beijing Fangshan High-end Industrial Base for Modern Manufacturing

2.2.3. Technology Competence & Economic Ability of the Cluster

Specific technologies and competences that is available in the cluster:

- New energy vehicle (Electric & Hybrid Bus, Electric utility vehicles, Electric taxi and passenger car)
- Infrastructure (the solution of battery charging/swapping station and smart grid) for electric & plug-in hybrid vehicles
- Key components technology for NEV: battery, Electric motor and controller, powertrain for electric bus
- The National Engineering Laboratory for Electric Vehicles (NELEV) at BIT has been involved in developing the E-Bus technology since 1994 (see below developing routine). NELEV has developed their own E-Bus Technology Platform and Powertrain for E-Bus, the technology has transferred to the top 10 bus producers in China.

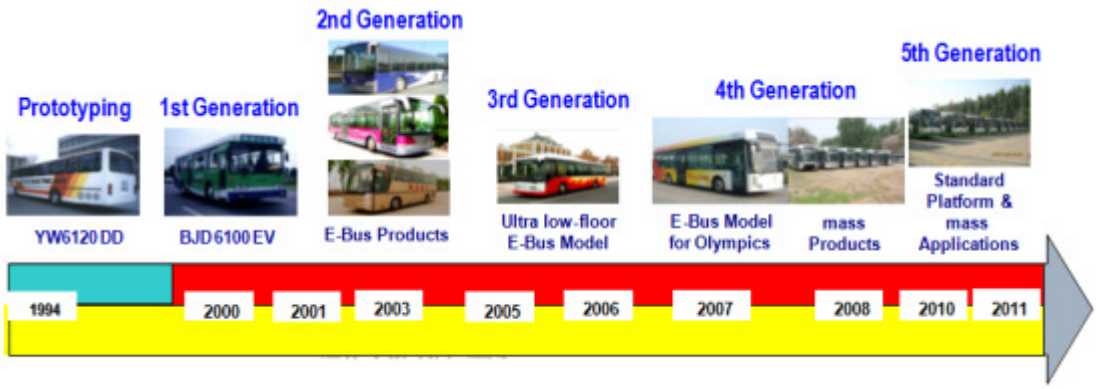

Figure 3: The history of NELEV developing E-buses technology

- Beijing was the first city in China which started E-bus demonstration program in 2001, and then spread E-bus demonstration program to Miyun District in 2003, Beijing Finance Street in 2006, Beijing Olympics games in 2008, China 10 cities with 1000 EVs each Demonstration Program in 2011
- Beijing Olympic E-Buses Team has made a lot of inventions when they made the idea of charging/swapping battery into practical application. Beijing Battery Charging/Swapping Station became the first successful scale operation in the world for 50 E-Buses in 2008. Thereafter, the solution and technology was transferred to Shanghai for 2010 Shanghai Expo E-Buses transportation, 2010 Guangzhou Asian Game and later other Chinese cities
- Beijing is also the first city in China to develop and apply electric sanitation vehicle fleet (1060 units in 2010)
- Beijing has established a standardization system for EV charging infrastructures including 16 Local Standards

2.2.4. Cluster organization management – technological focus and organizational capability

R&D Cluster:

There are 19 Developments Zones together in Beijing. Three of them are national level Developments Zones (about 77.7% of total development zone area) and 16 are municipal level (about 22.3% of total development zone)

- Zhongguancun Science Park, which consist of Haidian Science Park,Fengtai Science Park, Changping Park Zone, Electronics City, Yizhuang Park Zone, Desheng Park Zone, Jianxiang Science Park, Tongzhou Science Park, Shijingshan Science Park, Yonghe Science Park and Daxing Pharmaceuticals-related Research Base 11 Science Parks at different locations, involved in different High-Tech research fields, industries and modern manufactures. Each science park has their individual management institution.
- Beijing University National University Science Park was first established in 1992, which is one of China's earliest university science parks. In 2010, the science park broke through hundreds of millions output value, nurturing and gathering a passel of potential enterprises concerning the fields of biological medicine, electronic information, energy conservation and environmental protection and cultural innovation. The total project area of Beijing University Science Park reaches 37.7 hectare, and there are 550 thousand square meters of planned construction area invested with 8.9 billion Yuan, the operation of which after construction will bring about 200 billion Yuan of annual output value to the Haidian region, becoming the new increasing point of future regional economic development.
- Beijing is increasingly becoming known for its innovative entrepreneurs and high-growth start-up companies, a large community of both Chinese and foreign venture capital firms, such as Sequoia Capital, a larger proportion of tertiary-level institutions than in any other city in China (at least 70).
- Beijing is home to a great number of colleges and universities, including Peking University and Tsinghua University
- Beijing is home to Chinese Academic of Science, automotive association, automotive technology and research centre.

Policy context:

Selected milestones of electric vehicle policy support by Chinese Central Government:

- 2001: 863 EV R&D Projects – Government investment of RMB 800 million (US$127 million)
- 2006: 863 Energy-Saving and New Energy Vehicles Project – MOST invests RMB 1.2 billion (US$174 million), setting technology roadmap for the EV industry.
- 2008: 1000 Vehicles, 10 Cities Demonstration Project funded by MOST, MOF, NDRC, and MIIT
- 2009: Plan on Adjusting and Revitalizing the Auto Industry – State Council planned to invest RMB 3 billion (US$477 million) to develop key EV technology.
- 2010: Subsidy Standards for Private Purchase of New Energy Vehicle – MOST, MIIT, and MOF selected 5 cities for private EV purchase subsidy with maximum subsidies of RMB 50,000 (US$7,900) for PHEVs and RMB 60,000 (US$9,500) for BEVs.
- 2010: 863 Key Technology and System integration Project for Electric Vehicle – RMB 738 million (US$117 million) for battery and EV integration with 42% of funds for battery research.
- 2011: Vehicle and Vessel Tax Law was adopted at the National People's Congress and became effective on January 1, 2012. The regulations reduce or exempt vehicles that conserve energy or use new energy from certain taxes. Tax of traditional vehicles with displacement between 1.6 litres and 3.0 litres is lowered and that of the vehicles of 3.0 litres and above remains at a higher level.
- 2011: The Management Rules for Government Fleet Model Catalogue – The Rules became effective on November 14, 2011. According to the Rules, models for general government departments, including courts, police stations, and other law-enforcement organizations should be no larger than 1.8L in displacement with prices at RMB 180,00.

MOST--Ministry of Science & Technology; MOIIT-- Ministry of Industries and Information Technology; MOF--Ministry of Finance; NDRC--National Development and Reform Commission

Policy issued by Beijing Government in 2010 on development of NEV (new energy vehicle):

- Definitions of NEV will include HEV, BEV, FCEV, Hydrogen engine vehicle and other new energy source (such as high-efficiency energy storage system, dimethoxymethane (DEM) etc.) vehicle
- Government invests in special funds for breaking through technical bottle neck
- Encourage NEV corporations and research centres to register national projects, promise to give the proportional support from local government;
- Support industrialization, construction and advanced tech transfer projects for NEV with preferential taxation & exempt from Business tax;
- Support to establish the technical standard of NEV especially BEV;
- Establish the green pass to encourage new company or industry which has competitive technology for key components on NEV to settle down in Beijing;
- Prior approval on land for NEV development;
- 30% of cost of charging/swamping station born by government, Prior approval on charging station projects and land use for them

- Preferential taxation for battery renting industry for 3 years
- Financial institutes provide supports with credit and loan, warranty.
- Talents are prior to settle down; reinforcing brain cultivation.
- Encourage customers of E-bus, E-taxi, electric sanitary vehicles and electric post-office vehicles to get government subsidies;
- Reinforcing after-sales service of NEV, NEV producers should give customer 3 years or 150,000km warranty for battery.

Structures and processes of cluster management

Coordination Committee of Beijing NEV Projects
The role of the Coordination Committee is provide the strong support from policy and funds level in order to ensure NEV development plan in Beijing could be carried out and developed successfully

- Director: Mr. Zhao Fengtong, member of the Beijing municipal government standing committee. Deputy Director: Mr. Gou Zhongwen, Vice Mayor of Beijing; Mr. Huang Wei, Vice Mayor of Beijing
- Members: Officials from different departments of the Beijing municipal government such as Beijing Municipal Commission of Development & Reform(BMCDR), Beijing Municipal Science & Technology Commission(BMSTC), Beijing Municipal Bureau of Environmental Protection (BMBEP), Finance Bureau of Beijing (FBB) etc.;

Technical Expert Team

- Consisting of famous experts in the field of new energy vehicles: The team is under the leadership of the Coordination Committee and is responsible for providing technical opinion and support for policy, strategic development plan, project plan, research and technical breakthroughs, review and valuation projects, testing and analysis in the process of EV applications.

Activities/services for the benefit of the members

- Beijing Municipal Commission of Development & Reform(BMCDR)
- Beijing Municipal Science & Technology Commission(BMSTC): Together with BMCDR making general development strategy and planning projects fund for NEV
- Beijing Municipal Commission of Economy and Information Technology(BMCRIT): providing support for the industrialization of NEV and its key components
- Beijing Municipal Bureau of Environmental Protection (BMBEP): together with BMCT to carry out electric sanitation vehicles deployment project
- Beijing Municipal Commission of Urban Planning (BMCUP): responsible for the deployment plan of charging/swapping stations and charging points
- Beijing Municipal Commission of Transport(BMCT)
- Beijing Public Transport Holdings, Ltd. (BPT): together with BMCT to carry out EVs deployment project for public transportation
- Finance Bureau of Beijing (FBB): making funds plan and deploying funds for projects according to the policy
- Beijing State Grid: making charging/swapping stations and charging points according to BMCUP plan

2.2.5. Summary Beijing

Beijing is one of the most populous cities in the world, with a population of 19,612,368 inhabitants the second largest city by urban population after Shanghai. In 2010, Beijing's nominal GDP reached 1.37 trillion RMB. Its per capita GDP was 78,194 RMB. In 2011, Beijing's nominal GDP reached 1.6 trillion RMB. Its per capita GDP was 80,394 RMB (12,447 USD), a growth of 8.1% over the previous year. Beijing is a major transportation hub in the national highway, expressway, railway and high-speed rail network. Beijing Capital International Airport is currently the second busiest airport in the world and the busiest in Asia. Beijing is the country's political, cultural, and educational centre, and home to the headquarters for most of China's largest state-owned companies, national research institutions and professional organizations. Beijing is home to a great number of colleges and universities, including Peking University and Tsinghua University (two of the National Key Universities). Owing to Beijing's status as the political and cultural capital of China, a larger proportion of tertiary-level institutions are concentrated here than in any other city in China (at least 70)

Beijing Automotive Group (BAIC) is a state-owned enterprise and holding company of several Chinese automobile and machine manufacturers, such as Beijing Automobile Works Co Ltd, etc. Located in Beijing, Beiqi makes Hyundai and Mercedes-branded autos for sale on the Chinese market. 2011 production of more than 1,389,800 whole vehicles made Beiqi the fifth largest, in terms of units manufactured, vehicle-maker in China that year. The supportive policy and project funds from government guide the strong cooperation and networking partnership between universities, research institutions and industry. Every company (from industry) has partnered with a few universities, research institutions and other industry company according to company’s needs. The networking partnership is not only limited in Beijing region, but all over China. Not only existent large firm (Foton) and national research institutions are in the list of important stakeholders for NEV in Beijing, but also many start-ups and new engineering labs. The guideline and policy strong support play a very important role to attract large firm and new start-up companies to develop and invest in the new energy vehicles and green transportation. Owing to the strong support from both central and local government, Beijing EV technology team has developed their own technology and obtained many patents for EV technology platform, charging/swapping infrastructure, motor and its controller, battery and drivetrain. Many technology solutions and patents were developed by universities and industry through common projects.

Compared to Europe, there is no professional and clear automotive cluster organization existing in Beijing, but the system (the cooperation among the government, academic and research institutions, industry) works quite well and very effective regarding the roadmap development of new energy vehicles and green transportation.

2.3. SHANGHAI

The following description of the regional research and innovation eco system within green and safe is provided by a local contact in Shanghai, familiar with the region.

2.3.1. Background information

Shanghai is the largest city in the People's Republic of China. Shanghai is located at the Yangtzes delta towards the East China Sea on the east and Hangzhou Bay on the south. Thanks to its advantageous geographic location, Shanghai has become an excellent sea and river port, boasting easy accesses to a vast hinterland. Shanghai is the second largest financial centre in Asia, after Tokyo. It is also China's fastest growing and economically most important city.[15]

Shanghai at a glance:

- **Population:** 17, 8 million inhabitants
- **Area:** 2 606 km²
- **GRDP:** $297 billion (2011)
- **Major industry:** electronics and information technology, cars, power and large-scale electromechanical equipment, petrochemicals, high-grade steel and biopharmaceutical products.

Transport Infrastructure

The city's efforts to develop the subways and build a modern traffic network typical of a modern metropolis since 1990s have paid off, with its road network ranking the most sophisticated of its kind in the country. Today Shanghai can flaunt with four mega-bridges and 12 tunnels crossing the river Huangpu which separates the two parts of the city. In total more than 452 km of metro is available for the citizens of Shanghai. The city is a major hub of China's expressway network with many national, municipal and elevated highways.

Public transport in Shanghai is well developed and the region is very transport intensive with the largest harbour in the world.

- In 1908, it was initiated with trams constructed and owned by UK (Jardine Matheson)
- In 1949, 44 bus lines, 934 buses, transporting 0.237 billion person-times annually, highest in China
- In 1990s, 408 bus lines, 6562 buses, transporting 5 billion person-times annually,
- In 1992, reforming with bus IC card instead of monthly ticket
- In 2011, 1100 bus lines, 17000 buses, transporting 7.7 million person-times daily

[15] Overview video: '10 minutes and you know about Shanghai' in http://www.youtube.com/watch?v=-DOPQrVSHiY

Competitiveness and Economy

Shanghai ranks as number eight on the global financial Centres Index. The city is descried as the commercial and financial centre of mainland China. In 2011, total GDP grew to 1.92 trillion Yuan (US$297 billion), per capita of 82,560 Yuan (US $12,784). Shanghai has the world's busiest container port. Shanghai is also one of main industrial centres of China, some corporations: China's largest steelmaker Baosteel Group and Jiangnan Shipyard, SAIC Motor is one of the three largest automotive corporations in China, and has strategic partnerships with Volkswagen and General Motors.

Assets

- Automotive lab, Tongji University
- Shanghai New Energy Vehicle Inspection & Research Centre
- Shanghai E-drive Co. Ltd.
- National Fuel Cell Vehicle & Drive Line Technology & Research Centre, Tongji University
- New Energy Automotive Engineering Centre of Ministry of Education, Tongji University

Societal Issues

- Transportation: Weak attraction of city bus to citizen due to weak investment, disordering lane and impacted by metro
- Traffic stress specially rush hour due to residence density and increasing cars
- Emission pollution to environment from fossil fuel vehicle.
- Worsening polarization of rich and poor
- Most of laid-off people between age 40-50 are hard to be re-employed (Project 4050)
- Privilege policies less effect the low-income people to buy government subsidized housing
- Weak investment on public sanitation and medicine system
- Weaker education power in suburban than in downtown
- Dramatically high real estate price

2.3.2. Regional innovation system

This chapter describes the various players of the cluster and regional systems to support innovation.

Industry

SAIC Motor Corporation Limited (Shanghai Automobile Industry Co.): SAIC is a Chinese multinational automotive manufacturing company with its headquarters in Shanghai. SAIC products sell under a variety of brand names including those of its joint venture partners, Volkswagen, General Motors and Volvo. In 2010 SAIC produced 3.58 million units, the largest output of any China-based automaker.

Shanghai H&D EV Battery Co., Ltd founded in Jan, 2010. The registered capital is 100 million RMB, product: lithium-ion battery packs and battery management system.

DLG Power Battery (Shanghai) Co., Ltd. founded in Oct.2001. Product: lithium-ion battery packs. *Shanghai Leibo New Energy Co., Ltd.* JV of three shareholders, founded in 2007, product: power train of lithium-ion & super capacitor battery.

Shanghai Pylon Technology. The company offers series of power cells/packs and energy cells/packs as well as completed power systems.

Shanghai Jieneng Automotive Technology Co., Ltd. The company offers power and controlling system for hybrid and Electrical vehicle.

STK Shanghai Co., Ltd. (STK: Singapore Technologies Kinetcs). Offers power and controlling system for hybrid and Electrical vehicle.

Shanghai Fuel Cell Vehicle Power System Co., Ltd. The company was founded by SAIC & Tongji University and offers national key fuel cell project.

Universities and research institutes

Tongji University[16]*:* Tongji is one of the leading universities directly under the State Ministry of Education in China, key developing Universities of China Project 211 & 985. It include Sciences, Architecture and Urban Planning, Civil Engineering, Mechanic, Environmental Science and Engineering, Material Science and Engineering, Electronics and Information Engineering, Traffic and Transportation, Medicine, Liberal Arts and Law, Foreign Languages, Economics and Management, Software Engineering, Ocean and Earth Science, Automotive. The university Offers diverse courses in its 82 bachelor's Degrees, 218 Masters, 94 PhD programs and 16 post-doctoral mobile stations. As one of the state leading centres for scientific research, the university has 22 state key laboratories and engineering research centres. The faculties include 860 professors, 1380 associate professors, 35600 students, of which 19800 undergraduates, 15800 post graduates, 8800 On-the-job postgraduates, 3000 international students, area: 260 hectares, covering 4 campuses.

Shanghai Jiaotong University[17]*:* The university has 31 academies (departments), 63 undergraduate programs, 250 masters-degree programs, 203 Ph.D. programs, 28 post-doctorate programs, and 11 state key laboratories and national engineering research centres. SJTU boasts a large number of famous scientists and professors, including 33 academics of the Academy of Sciences and Academy of Engineering, 92 accredited professors and chair professors of the "Cheung Kong Scholars Program" and more than 1,900 professors and associate professors. It host 42,881students, of which 1,598 are international students. There are 17,766 undergraduates, and 24,017 masters and Ph.D. candidates. More than 200 of the academics of the Chinese Academy of Sciences and Chinese Academy of Engineering are alumni of Jiao Tong University. Major academic fields are Engineering, Sciences, Life Medical Sciences, Humanities & Social Sciences.

Other universities are *Shanghai Automotive Industry Science & Technology Development Foundation:* Founded in Feb.1996 as per document of Shanghai Branch of People's Bank of

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[16] Source: http://www.tongji.edu.cn/english/
[17] Source: http://en.sjtu.edu.cn/

China (PBC), 60 million RMB donated from SAIC. Most of universities in Shanghai were the members; *Shanghai University Student's Hi-tech Entrepreneurial Foundation:* Invested by Shanghai government, for most of Shanghai universities; *Shanghai Automotive Educational Foundation:* Founded in Jan 1993, approved by Shanghai Branch of People's Bank of China, audited by Shanghai Civil Affairs Bureau, initiated by SAIC, nowadays funds of 30 million RMB.

Governmental and other public organizations

No.	Lead Organizations	Responsibility
1.	Shanghai Municipal Development & Reform Commission (SMDRC) Shanghai Municipal Commission of Economy and Informatization (SMCEI)	Actively engaging national planning & policy, try to get state support
2.	SMCEI, SMDRC	Formulating developing programs for new energy vehicle industry
3.	SMDRC, SMCEI, Shanghai Municipal Financial Bureau(SMFB), Shanghai Municipal Local Taxation Bureau (SMLTB) & associate districts + county	Accelerating issuing special supporting policy and measurements
4.	SMFB, SMDRC, SMCEI	Set up special funds for new energy advancing tech industrialization
5.	SMCEI etc.	Reinforcing establishing industrial chain of complete vehicle & part/components
6.	Science & Technology Commission of Shanghai Municipality (STCSM)	Reinforcing tackling technical issues on key raw material
7.	Shanghai Urban Construction & Communications Commission (SUCCC), SMDRC, Districts, Counties,	Augment demonstrations & application of new energy products
8.	Shanghai Municipal Government Offices Administration Bureau(SMGOAB), Districts, Counties	Augment Government Procurement on new energy product
9.	Shanghai Municipal Human Resources and Social Security Bureau (SMHRSSB)	Reinforcing the introduction on the elite of new energy industry and excellent team
10.	Shanghai Municipal Education Commission (SMEC)	Reinforcing Curriculum Construction, accelerating talent cultivation

11.	SMCEI, STCSM	Accelerating public service architecture construction, completing industrial technical support system
12.	Pudong new district, Jiading District, Minhang District, Fengxian District, Songjiang District and relativities	Reinforcing new energy industry base construction, promoting foreign trade & investment,

Table 1: Overview public organizations Shanghai

Provisions on Promoting the Development of Shanghai New Energy Vehicle Industry (SMDRC, SMCEI,) (Nov.11, 2009):

Special Funds; Venture Capital Investment Steering Funds

Applying municipal level of Special Support Funds on re-generating energy & new energy development for 2010 & using plan for 2011

Preferential Tax Policy for New Energy Industry Ministry of Finance, State Administration of Taxation (SAT)), valid Jan.2009 – Dec. 2011.

Professional organizations, e.g. chambers of commerce:

- Shanghai Federation of Economic Organization (SFEO, founded in 1991, administrated by SMCEI, members:300
- Shanghai Federation of Industrial Economics (SFIE= SFEO)
- Shanghai Federation of Industry and Commerce, founded in 1951, members: 28276
- Shanghai Automotive Trade Association (SATA), founded in 1996. Memebers:307
- Shanghai Automobile Sales Trade Association (SASTA） memebers:176
- Shanghai Automotive Parts Circulating Trade Association, (APCTA） founded in 2002, members: 450
- Shanghai Enterprise Confederation (SHEC） founded in 1979, members:5000
- Shanghai International Cooperation Association of Small and Medium Enterprises founded in 1993, members:300+
- Society of Automotive Engineers of Shanghai, SAE_S founded in 1987, members 1200
- Shanghai Energy Conservation Association founded in 1985,
- Shanghai Intellectual Property Administration

Business incubators:[18]

- Shanghai Huigu Hi-tech Creation Centre: invested by SH Jiaotong University, services: site renting, tax registration, funds recommendation, hi-tech product

[18] Source: Shanghai R&D Public Service Platform (SGST)
http://library.dhu.edu.cn/english/pages/common_shangh.aspx

verification, training, forum, management consult, information, intermediary, international communication, investment & financing.

- Shanghai Jiading Hi-tech Park Development Co.: founded by SMSTC & Jiading Government, major for venturing from abroad people. Service: site offering, registration, capital consult, patent protection, applying project approval & funds
- Shanghai Xinmin Hi-tech & Overseas Returned Student Science & Technology Creation Park, founded by STCSM & SH HR Bureau. Services: Registration, funds support (loan, applying subsidy & funds, credit security, tax awards), talent hunting, settlement, housing)
- Shanghai Jiaotong University Science & Technology Research Centre, founded by SJTU, SH S&T Creation Centre and the journal – Science & Technology Venture. Service: Practice, training & consult, trusteeship, info & market investigation, compiling documentation.
- Shanghai Tongji Science & Technology Park Incubator Co. Ltd., strongly supported by SH S&T Venture Centre. Services: Interactive development, consult, technology promotion, financing & anything related to Science Park.

Science parks:

- Jiading Automotive Industrial Park: base of NEV + P&C, with the comprehensive function of R&D, manufacture, test, demo operation & service;
- Pudong Jinqiao Export Processing Zone + Pudong Lingang Key Industrial Base +Jinshan Fengjing Industrial Park: base of industrialization for new energy passenger car
- Minhang Xinzhuang Industrial Park, Songjiang Industrial Park, Pudong New District: base of industrialization for new energy commercial vehicle

Technology transfer agencies:

- Science & Technology Commission of Shanghai Municipality (STCSM)
- Shanghai Technology Transfer & Exchange Institute (STTE), founded by M. Science & Technology and SH government in 1993
- Shanghai R&D Public Service Platform (Internet web: SGST)
- Shanghai Technology & Market Administration Office (STMO)
- Shanghai Torch Hi-tech Industry Development Centre (Torch centre, led by STCSM, provides comprehensive services.
- Shanghai New High Technology Service Centre, founded by SH municipal government in 1998, services: Dissemination, training, consult, coordination, analysis, assessment, one-stop service with governmental Departments and all other comprehensive managements.
- Shanghai United Assets and Equity Exchange Institute (SUAEE) services: financing with property exchange, stock equity transfer,
- Shanghai Jiaotong University State Technology Transfer Centre Service: searching partnership with technology

Fund raising:

- National Key Science & Technology Project Shanghai Local Allocating Fund Program, operated by State Key S&T Funds Administration Office
- Pudong Science & Technology Venture Talents Support Fund, set up by Pudong Science & Technology Bureau

- Pudong New District Science & Technology Special Fund, set up Pudong New District Science & Technology Development Organization
- Magnolia Science & Technology Talents Fund: set up by STCSM & SH Finance Bureau
- Shanghai Science & Technology Development Fund, set up by Basic Researching Division of STCSM
- Shanghai Scientific Small & Mid Entrepreneur Technology Creation Fund set up by STCSM.

Regular events that can act as collectors of stakeholders e.g. fairs, networking events etc.

- China Shanghai New Energy Auto Show, Yearly, Nov1-5, place: Shanghai New International Expo Centre.
- China (Shanghai) International New Energy Vehicle & Charging Equipment (EVCE), yearly, will be June 26-28, 2012, place: Shanghai World Expo Exhibition And Convention Centre
- China (Shanghai) International Battery Industry Fair (CNIBF), Oct16-18, 2012, Place: Shanghai New International Expo Centre
- Shanghai International Automotive Exhibition, April, each odd Year. Place: Shanghai New International Expo Centre
- Bus World Asia Shanghai, /each odd year. will be March 20-22 2013
- CGTTS China International Energy-saving & NEV Technology Expo (EV China + Bus Tec), Oct17-19 2012, place Shanghai world Expo Exhibition and Convention Centre
- 2nd Shanghai International New Energy Vehicle Summit 2011 (Oct17-18), organizer: Jiading Government

Innovation platforms

- www.sgst.cn (Shanghai Guidance of Science & Technology
- Shanghai Municipal NEV Industry Technical Innovation Service Platform, Members:
  - Tongji University;
  - National Centre of Supervision & Inspection on Motor Vehicle Quality <Shanghai>
- Shanghai Municipal New Energy Vehicle Promoting Office found in 2006, administrated by Equipment Department of SMCEI Task: Promoting electric vehicle development & application as per policy

2.3.3. Technology competence and economic ability of the cluster

There is the most comprehensive/largest/diverse automotive P&C industrial base in Shanghai, where it is considered as one of the best regions for automobile investment & industrialization by industrial & academic circles. New energy bus, passenger car, touring bus & taxi: hybrid, fuel cell, battery, super capacitor.

Investment on R&D:

- 0.4 billion RMB for NEV engineering centre of Tongji University in 2002;
- 2.5%-2.9% of sales income of SAIC is for NEV;
- 53 subordinates were identified as hi-tech enterprises,

- 2 state-level enterprise tech centres,
- 10 municipal-level enterprise tech centres;
- 2825 applied patents; 2018 authorized patents;
- 33 China's automobile industry and technology progress awards; 23 Shanghai's science & technology progress awards

Investment on HR:

- Leader /talent training + selection for 4 times
- "Thousand People Plan" aiming at expatriates
- Settlement supporting policy
    - Demand of NEV car: 8 private NEV cars were licensed to be operated on street in Apr.2011; 20.000 private NEV cars will be launched in the end of 2012
    - Demand of NE commercial vehicle: 4884 NEBs in China in 2010, of which 598 is in Shanghai (12.2%), where it is the key demanding region.
    - Matured development on battery (to be further solved), motor, controlling
    - Auxiliary infrastructure (power supplying, charging station, customer convenience) takes shape
    - Enhancing enterprise strategy, structure and market competition
    - Governmental activities: specialized funds, governmental purchasing, purchasing allowance and tax preferential or deduction
    - Shanghai NEV Industry has been "R&D centre", "Test centre", "Regulation Centre" & "Assessment centre" for NEV field in China
    - Shanghai intended to issue "The 12th Five-year (2011-2015) Planning on NEV", so far it has not been opened. It is being re-updated as per China "Develop Planning on Energy-saving & NEV Industry (2012-2020)

Quantity, 2010					Planning 2011
City	**NEV**	**Hybrid**	**EV**	**Other vehicle**	
Beijing	961	870(bus)	100 bus (50 in operation)	30 E Sanitation 11 fuel cell Bus 30+ bus line	Taxi:+50 EB: +170 ESV:+1000
Shanghai	1300	150(bus) 350(car)	150(bus) 150(special)	6 FC bus (Sunwin) 90 FC car (SAIC, Chery, VW, GM, Chang'An) 100 FC tour bus (7~11 seats without door, SAIC) 61 supercapacity bus 30+ bus line	2012: E-car:19000 Plug in Hybrid:1000
Chongqing	80	50(bus) 20(taxi) 10(van)			EB: +20

Hangzhou	800	500 (bus)	369(bus+taxi)		20000 (private)
Wuhan	500	bus+car	bus+car	58 bus line	+ 2 bus lines 400 H buses 600 H cars 500 E buses
Changchun	220	200 (bus)	20 (bus)		+ 1000 H buses, 2 fleets
Ji Nan	100	bus			2011: +100 H buses 2012: 1610 NEV
Nan Chang	300	63 bus 100 taxi 70 van	7 bus 30 Taxi 30 Van		+60 H buses +10 E buses +3 bus lines +110 H taxi +10 E taxi +70 H van +10 E van +5 E Sanitation V +15 E postal vehicle
Dalian	300	100 taxi 162 bus 50 car(Buck)	10 bus		+400 H car
Shenzhen	389	339 bus	50 Taxi		+ 850 H bus + 100 E taxi
Kunming	135	83 Bus	2 Bus 50 H/E taxi		+100 H bus +500 E bus
Hefei	700+		100 bus 585 car		2012: 14500 E car 8000 plug in H car
Changsha	150+	bus	bus		2012: 21000 NEV; Within 3 years: 2000 E taxi

Table 2: Overview of plan for NEV in China

- Policy incentives: subsidy, funds, interest deduction
- April 22. 2011, Shanghai was honoured with "China (Shanghai) International Demo City for EV ", Jiading was appointed as Demo District for EV, In Jiading, two EV clubs, EV Forum, Fair, challenge match, three EV centres were established or performed.
- New energy buses operated for Shanghai Expo got valuable effect.
- Serial new energy passenger car will be in production during end of 2012.
- Much R&D was invested on battery, motor and controlling system.

- Fuel cell car of SAIC participated Bibendum Challenge Match in Germany, won the 3rd rank just behind Toyota & Audi.

2.3.4. Cluster organization management – technological focus and organizational capability

Structures and processes of cluster management

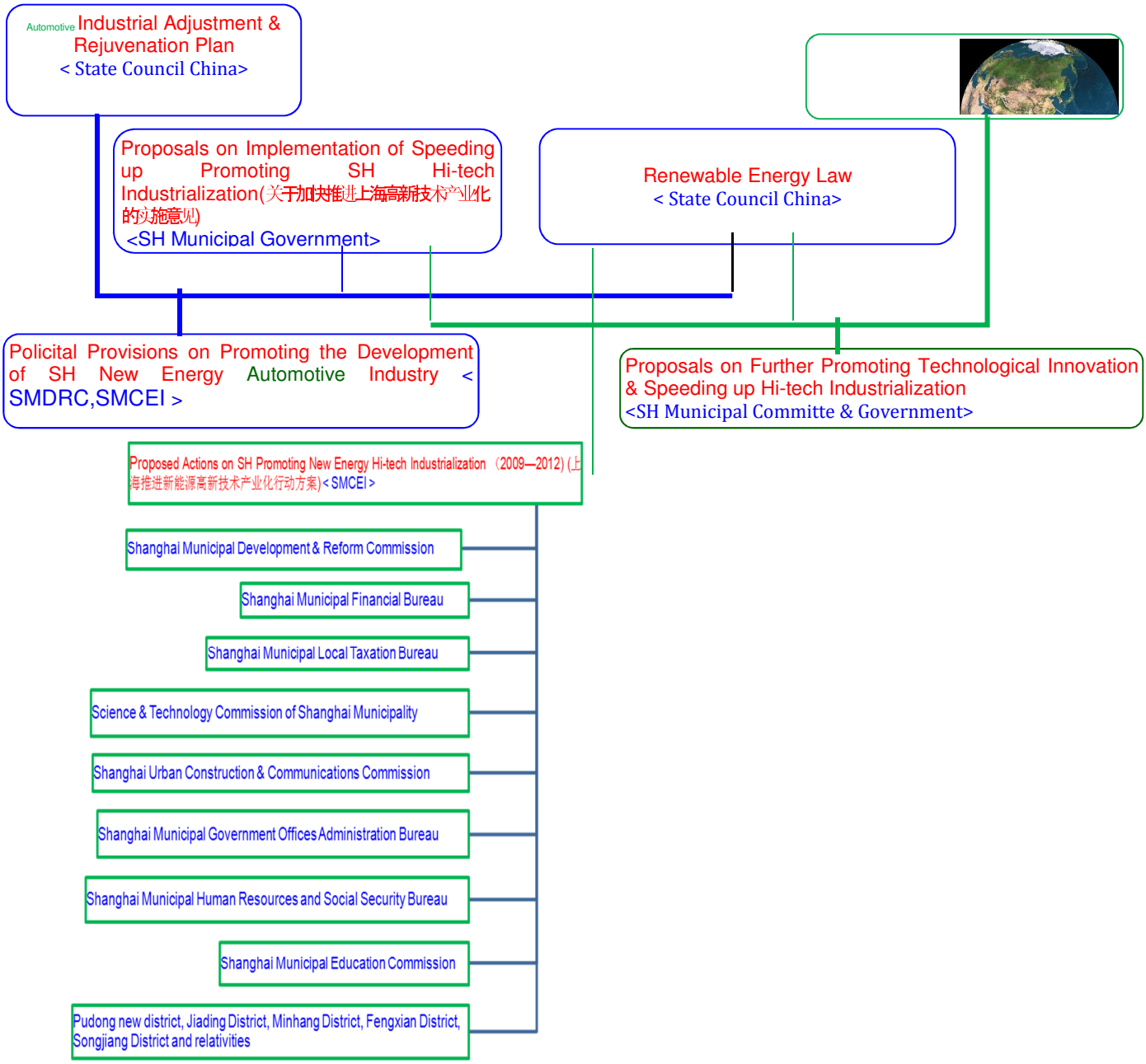

Figure 4: Structures and processes for cluster management

Activities/services for the benefit of the members

SMFB, SMDRC, SMCEI set up special funds for NEV.

2.3.5. Summary Shanghai

Shanghai is centrally located along China's prosperous eastern coastline at the mouth of Yangtze River delta. Thanks to its strategic location Shanghai has become the country's premier sea and river port. Shanghai harbour is the largest one in the world. The huge amount of goods passing through Shanghai affect the need for transportation and Shanghai is well developed when it comes to both public transport and road networks. The fact that Shanghai is the largest city in China also affects the need for efficient transport.

Due to its location and size Shanghai is identified as an ideal location for manufacturing. The regional government strongly supports research and innovation and Shanghai is acknowledged as a region with good investment climate.

Shanghai has the ambition of building NEV industry cluster working within the areas of hybrid techniques, electric vehicles, battery technology development, motor development and control system development. The district of Jiading is identified as a national demonstration city for new energy vehicles and is the first international demo city of this kind.

Since China historically has not done so much research on battery and control system technology, compared to for example Europe, much of the techniques used to build new energy vehicles rely on import. There is a strong push from Chinese government to increase indigenous innovation within these areas and this is seen as one possible collaboration area.

SAIC Motor Corporation is the largest automotive manufacturing company with its headquarters in Shanghai. SAIC products sell under a variety of brand names including those of its joint venture partners, Volkswagen, General Motors and Volvo. In 2010 SAIC produced 3.58 million units, the largest output of any China-based automaker.

Tongji and Jiaotong are the largest universities in the area and have already important collaboration with many OEMs, universities and organizations in Europe.

2.4. XI'AN REGION

The following description of the regional research and innovation eco system within green and safe is provided by a representative from the SAGE partners situated in Europe but with a Chinese background and local contact connections to the area of Xi'an.

2.4.1. Background information[19]

Xi'an, Shaanxi Province, China. Figure 5 shows the location of the metropolitan, which are 1,100 km from the national capital Beijing and 1,400 km from Shanghai. The city is located in the middle of China and is the most important city in the vast North-western area of China. The city is situated almost at the same latitude as Los Angles in USA and Rabat, capital of Morocco in North Africa.

Xi'an is the capital of Shaanxi province and a sub-provincial city in China, i.e., the city government has the equal right as the provincial government in the economic area. With more than 3,100 years history, the city boasts its glorious role in ancient China. Since the 1990s, Xi'an has re-emerged as an important cultural, industrial and educational centre of the central and north-western region, with advantage on research and development, national security, Chinese space exploration program. In recent years, the provincial and city governments are determined to strengthen the automotive industry. For example, Xi'an is the manufacturing centre of BYD cars.

Xi'an is one of the most populous metropolitan areas in inland China with more than 8 million inhabitants. It is the major transportation hub in the central and north-western region.

Xi'an at a glance:

- **Population**: 8,5million inhabitants
- **Area:** 9 983 km²
- **GRDP:** $3397 (2011)
- **Major industry:** an important cultural, industrial and educational center of the central-northwest region, with facilities for research and development, national security and China's space exploration.

Figure 5: The Geographic Location of Xi'an

[19] Source: http://www.xainvest.gov.cn/en/zrhj.asp

***Transport infrastructure*[20]**

Although Xi'an is far from the coastal areas in the east, the city has the potential to be a catalyst for development in the west thanks to its inland port. Backed by supporting policies from the national and provincial government, development of a logistics park in the area is gaining momentum. The city's convenient railway, highway and air transportation systems allow the park to improve the efficiency of logistics and reduce costs. Coordinated logistics services can help promote the clustering of industries and propel the development of a modern service industry.

Xi'an is the fourth biggest international aviation hub city in China and the largest transportation hub in northwest China. Zhengzhou-Xi'an high-speed train putting into operation symbolized the arrival of a new 350-km high-speed railway era in Xi'an. The rapid development in railways, aviation, freeways, main roads, and inter-city express roads has linked Xi'an up to the country and world by a convenient three-dimensional transportation network, bringing Xi'an prosperous development opportunities. In the field of aviation, Xi'an Xianyang International Airport is a major airport of domestic flight courses and international airliners. In the field of railway, the Longhai-Lanxin Railway Line (double-track) passing through Xi'an is the second Eurasia Land Bridge. The Longhai Line joins in Xi'an with other five local lines (Xi'an-Yuxia, Xi'an-Tongchuan, Xi'an-Houma of Shanxi, Xi'an-Yan'an, and Xi'an-Ankang) formed the largest railway communications hub in the northwest. In 2009, the passenger transporting volume of Xi'an railway was 25.85 million person-times and that of cargo was 6.14 million tons. In the field of highway, Xi'an has become one of the cities with the most concentrated national high level highway connections, where two state highway arteries, three major westward passenger routes and five state highways intersect. In addition, seven provincial highways radiate from Xi'an or around it. In recent years, several freeways have been built and connected through Xi'an, such as Baomao Line and Xikang Freeway. These trunk lines will connect ten peripheral major cities (namely, Taiyuan, Shijiazhuang, Zhengzhou, Wuhan, Hefei, Chongqing, Chengdu, Lanzhou, Yinchuan and Baotou) and thus form a "One-day Transportation Circle", which totally has 11,895km of highways. In 2009, the passenger transporting volume of Xi'an highways reached 252.71 million person-times and that of cargo is up to 299.86 million tons.

Competitiveness and Economy

Today, Xi'an has become an important base of scientific research, higher education, national defence and hi-tech industries, as well as a centre of finance, science & technology, education, tourism, business and trade, radiating to the Midwest region of North China. The year of 2010 witnesses Xi'an to be designated as one of the first national innovative pilot cities. Xi'an will grow to be a top-tier national innovative city with international influential power from 2015 to 2020.

The most noticeable advantage of Xi'an is its large number of universities and research institutes. The population of university students in Xi'an is next to only Beijing and Shanghai. The city is rich in educational and research resources. It has a self-sustained industry system of advanced manufacturing, electronics, aerospace and aeronautics, automotive industry, etc.

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[20] Source: Xi'an Municipal Development and Reform Commission www.xadrc.gov.cn

Xi'an has established direct trading relationship with nearly 150 countries and regions in the world. Focusing on optimizing the structure of export products, Xi'an realized a leap from exporting primary products to finished industrial products. Mechanical and electrical products, minerals, agricultural and textile products became the export pillars, and the export proportion of mechanical and electrical products as well as hi-tech products rose to 64.7%. In 2009, the total exports and imports of Xi'an reached US$ 7.255 billion, increased by 3.4%, of which the total exports were US$ 3.33 billion.

By the end of 2009, Xi'an had ratified to establish 2,783 foreign-invested enterprises with the contracted foreign investment of US$ 10.528 billion. The accumulative actual foreign investment amounted to US$ 7.531 billion, in which the actual foreign investment totalled US$ 1.32 billion in 2009, up 5.5% over 2008. Among the foreign investors in Xi'an from 59 countries and regions, there are nearly one hundred Global Fortune 500 enterprises. The pattern of the foreign investments in Xi'an in 2009 featured rapid growth in foreign capital stocks, expanding average scale of single project, aggressive asset increase of enterprises, and increasing number of sole foreign-funded enterprises. Foreign investment undoubtedly was a great contribution to Xi'an's economic development. Xi'an had accumulative actual overseas loans of US$ 675 million including foreign governmental loans, international financial organization loans from financial organizations and international commercial loans, most of which had been invested in the field of urban infrastructure, inclusive of water supply, gas supply, telecommunication and sewage disposal.

Automotive history

The annual productions of the automotive industry in Xi'an from 1995 to 2004 are plotted in Figure 6 below. One can observe three sections in the figure. The development in 1995-1999 was slow, with about 30% increase in total. The development in 1999-2001 started to be faster, with about 40% increase in total. The development took the high speed since 2001 and kept the momentum for 4 years. The total production value in 2003 was around 7.8 billion Yens and the amount of produced vehicles was 41944. Compared to 1995, the production value was around 4 times higher and the total vehicle amount is around 7.7 times higher. The total production value in 2004 is 11 billion yens and the amount of produced vehicles was around 50 000. Evidently the capability and competitiveness of the automotive industry in Xi'an are tremendously improved.[21]

[21] Source: Xi'an Municipal Development and Reform Commission www.xadrc.gov.cn

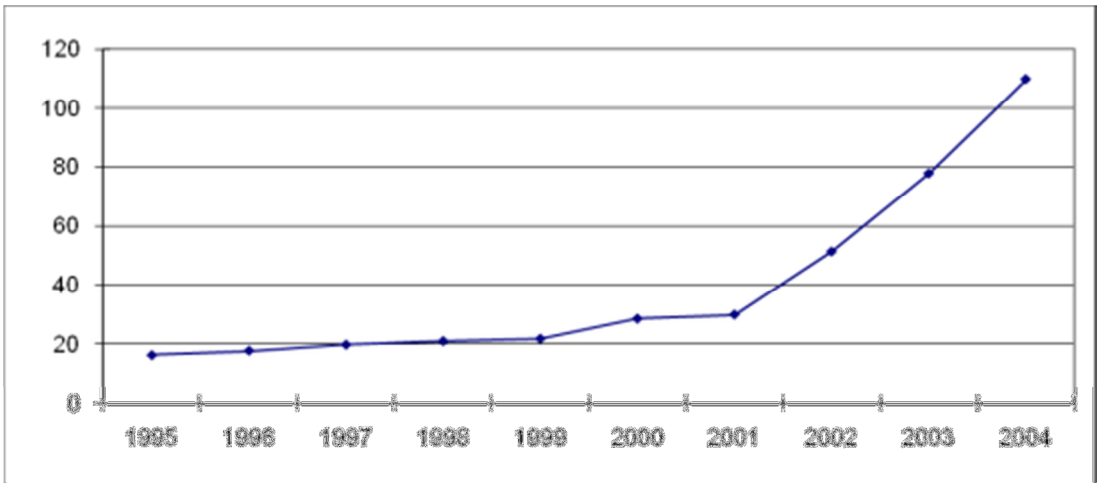

Figure 6: Annual Production (0.1 billion Yens) of the Automotive Industry in Xi'an from 1995 to 2004

In year 2006/2007, the total production amount was around 106 000 vehicles and the total value about 17 billion yens. After 5 years intensive investment and support from the city, the automotive industry in Xi'an got substantial increase. In year 2009, the production amount was 506 800 vehicles, an increase of 89% compared to the previous year. The most notable automotive corporations in Xi'an area are Shaanxi Automobile Group, BYD, and Shaanxi Fast Auto Drive Group. In year 2011, the total production amount from January to November was 497 200, which is unfortunately smaller than the previous year. Xi'an Municipal Development and Reform Commission have set up the ambitious plan of reaching the total production value of 110 billion yens by year 2015.

In the last decade, Xi'an has been gradually increasing the investment to the automotive industry. The total investment from the city finance from 2000 to 2004 was around 1.6 billion Yens, which was much larger than the investment during the previous 5 years. Thanks to the powerful investment, the profit of the automotive industry has significantly increased. In year 1999, the automotive industry in Xi'an lost 67.85 million Yens. The profit in 2004, in contrast, was around 0.7 billion Yens. The change is remarkable. For the time being, the automotive industry in Xi'an is leading other industry sectors in terms of product value and revenue.

After more than 20 years high speed development, three major corporations have become the leaders of the automotive industry in Xi'an, including Shaanxi Automobile Group, BYD, and Shaanxi Fast Auto Drive Group. Shaanxi Automobile Group was on the top 500 enterprises in China in 2003, and is among the 50 most promising automotive companies in China. Its comprehensive capability is ranked as 45 in the list of 500 best mechanical engineering companies in China. Ranked as number one in Shaanxi Province, Shaanxi Automobile Group is the largest manufacturing centre of heavy duty automobiles in Western China and is ranked as the 5th in China in terms of the production capability of heavy duty automobiles. Moreover, Volvo Buses used to have a joint venture in Xi'an, which produced high-end large buses. For unknown reason, unfortunately, Volvo Buses Corporation has stopped the collaboration in Xi'an. BYD is the primary manufacturer of private cars in Xi'an.

Having analysed the overall progress, Xi'an Municipal Development and Reform Commission drew the following conclusions: The profit in the automotive industry is steadily improving, which lays a solid foundation for future sustainable development and larger competitiveness. The investment into the automotive industry is significant.

2.4.2. Regional innovation system[22]

This chapter describes the various players of the cluster and regional systems to support innovation. The majority of the innovative activities are committed by the universities in this area. A few research institutes, like *Xi'an Institute of Optics* and *Precision Mechanics of China Academy of Science*, also have the excellence to carry out independent researches. Most of these institutes have links to military technology/or space exploration project. They may hold the leading position in China or even the world for some special technology areas. The industry is often collaborating with the universities and institutes for innovative R&D development, specifying technical requirements and providing financial support. Certain large corporations, like *Shaanxi Automobile Group*, are active on applying public funding from, for example, *National Natural Science Foundation of China (NSFC).*

The universities and institutes in Xi'an receive a large amount of research funding from national, provincial, and city funding agencies. For example, *Xi'an Jiaotong University* received 0.8 billion Chinese Yen in year 2010, ranked as the 12th in all Chinese universities. Northwestern Polytechnical University received 0.6 billion Chinese yen, ranked as the 15th, and *Xidian University* received 0.4 billion Chinese Yen, ranked as the 18th.
There are a few dedicated research centres and key laboratories in Automotive Engineering in Chang'an University, Xi'an Jiaotong University, and Northwestern Polytechnical University. These centres can grant Bachelor, Master, and PhD degrees in Automotive Engineering. These universities have excellent research facilities and capabilities, and are the preferred academic partners of the automotive companies in Xi'an and China.

The funding amount of the research institutes is difficult to estimate because many institutes, thanks to their military background or confidential nature, received large funding directly from the customers. For those projects prioritized by nation or army, the funding is indeed endless.
The city is active in attracting overseas investment. For instance, Volvo Buses Corporation has a joint venture in Xi'an. In year 2010, Xi'an received around 1.6 billion US dollars from overseas investment, which is a 28.5% increase compared to the previous year. The city has allocated two special economic zones to give foreign companies additional benefits such as start-up financial support, tax reduction, and cheap/free business facility.
On February 29, 2008 National Development and Reform Commission (NDRC) awarded Xi'an as one of the six biggest hi-tech industries bases of China, together with Beijing, Tianjin, Shanghai, and Shenzhen, and Xi'an became the only one integrated national hi-tech industries base in Western China.
Revolving around industries of information, biology, civil aviation and spaceflight, new materials, and new energy, etc., Xi'an Integrated National Hi-tech Industries Development Base will, depending on innovation of system, mechanism, and technology, take further steps to integrate and make use of technological and industrial resources, enhance core competitiveness, make efforts to realize industrialized and large-scaled high techniques, and construct industries cluster with international competitiveness in such fields as aerospace, biology, information, new materials, and new energy, etc., to build Xi'an into a first-class

[22] www.xainvest.gov.cn/en/xaxqjs.asp

internationalized, specialized, diversified, and centralized integrated hi-tech industries base in China, and further promote Xi'an's economy to develop soundly and quickly.

As announced in April 2012, Samsung has decided to start a new production base in Xi'an, which is the largest foreign investment in electronics and information technology since the establishment of new China. The new base will likely change the national distribution of IC industry. The first investment will be 7 billion USD to build the factory of the memory chip.

Industry

The following is an incomplete list of the high-tech corporations in Xi'an area. These corporations have close connection with automobile and transportation. The corporations with strong military background are deliberately avoided in the list.

Shaanxi Automobile Group[23] was founded in 1968. After more than 40 years development, the corporation now occupies 6.2 million square meters, owns 29.2 billion Yen, and employs 33 thousand employees. The enterprise focuses on the design, development, manufacturing and service of commercial vehicles. It is the largest manufacturing enterprise and the unique corporation on new energy commercial vehicles in North-western China. The comprehensive capacity is ranked number 250 in Chinese enterprises, and ranked 24th among all mechanical engineering corporations. In 2011, the enterprise has sold 120 thousand vehicles and the sales income was 31 billion Yens. Among them, there are 100 thousand heavy duty trucks and about 10 thousand are exported to other countries. In the field of new energy vehicles, the Group has developed CNG, LNG heavy-duty gas trucks, CNG, LNG bus chassis, flex-fuel, hybrid-electric, full-electric mini-vehicles and low speed vehicles. The group has active collaboration with the university, such as Xi'an Jiaotong University, and has rich experiences on applying national research funding.

Suda Transport Group was founded in 1996 in Samenxia city, which is 234 km away from Xi'an. I still count this enterprise in this report because Prof. Binggang Cao of Xi'an Jiaotong University is leading the development and commercialization of full electric vehicles there under committed support of the Henan Province. The developed FEVs possess many independent IPs and patents in China. On September 12, 2010 FEV prototypes with national and even international pioneering technologies were unveiled. At the end of 2010, there were totally 200 prototypes. These prototypes can reach the highest speed of 150 km/h, and the range is more than 260 km.

Shaanxi Fast Auto Drive Group[24] is the largest specialized production enterprise and exportation base in China, mainly for heavy-duty auto transmissions, auto gears, forgings and castings. In 2010, Fast Group has finished the output and sales of transmissions over 850 thousand units and realized industrial output value and sales revenue over RMB 12.6 billion. It has become the first enterprise of over RMB 10 billion of both the sales revenue and the industrial output value in Chinese Gear Industry. Each operation index of Fast Group ranks the first in the national gear industry for 9 successive years and the annual output and sales of heavy-duty transmission has ranked the first in the world for 5 successive years. Fast Group

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[23] Source: http://www.sxzq.org/
[24] Source: http://www.chinafastgear.com/defaultroot/english/

ranks top 10 tax-paying companies in China gear industry, top 30 in China automobile industry, Top 100 in China machinery industry, Top 500 in China manufacturing industry. Fast Group has strong and solid R&D capability, and with more than 40 patents and many types of its transmissions have the honor to win "Sci-Tech Progress Award of Chinese Automobile Industry", "Special Award for Outstanding New Products" by the state gear industry and "Science and Technology Award of Shaanxi Provence".

Shaanxi North Dynamic Co., Ltd[25] is a macro internal-combustion engine and auto parts manufacturer in China. In the past nearly 60 years, the company has established a completed R&D, manufacture, and detect, marketing and quality assurance systems. The company covers 870, 000 and owns over 2,000 staff ,which includes more than 600 engineering and other major management officers, and has the rich experience in R&D. There are 1,600 varies of equipment and over 10 different product lines. The company develops and manufactures DEUTZ 413/513 series air-cooled diesel engine, engine parts, pumps and filters, motorcycle, gasoline generators, mining machinery, Ti-joints series products.

Universities and research institutes

Chang'an University is a public university emphasizing transportation and vehicle engineering. The university has about 30,000 students and 1,700 faculty members, including 230 professors and 530 associate professors. Chang'an University used to be managed directly by the Chinese Ministry of Transportation and hence still retains a close tie to the ministry of Transportation. It is the unique university in China with its own high-speed vehicle testing ground. Among many schools, the School of Automobile is the largest research and education institute dedicated to the automotive engineering in Xi'an. According to a study by Wuhan University, Research Centre on the Evaluation of Chinese Science and Technology, Chang'an University is ranked number 1 among all Chinese universities in the field of Transport Engineering.

Xi'an Jiaotong University is the best university in Xi'an area, hosting about 30,000 students including about 13,000 graduates. It presently has 2500 full-time teachers including 1400 professors and associate professors. The Institute of Electrical Vehicles and Systems Control is dedicated to new energy vehicles. The institute belongs to the School of Mechanical Engineering and the director is Prof Binggang Cao. There are 12 senior faculties in the institute, including four professors, five associate professors, and three assistant professors. Prof Cao is a pioneer on the research of electrical vehicles in China. He and his research team have made a large number of contributions on electrical vehicle technology, fuel reduction technology, and robotics, publishing over 200 papers on international journals and conferences. He enjoys two international design patents and 21 national patents. The institute has received financial support from the 985 program and completed two electrical vehicle prototypes. Professor Cao is also the leader of the Department of Vehicle Engineering at Xi'an Jiaotong University. Currently Professor Cao is leading the commercialization and industrialization project of full electrical cars in Henan province. A group of researchers in the institute are collaborating with Shaanxi Automobile Group on the electric differential

[25] Source: http://bfdl.no16.cuttle.com.cn/en/index.php

mechanism of full electrical vehicles. The primary target is to replace the mechanical differential module with four cooperating wheel motors.

Northwestern Polytechnical University is traditionally dedicated to Chinese aeronautics and aerospace. It has more than 25,100 students including 3,100 doctoral students and 6,100 master students. The university has more than 3,900 full-time faculty members including 1,300 professors and associate professors. It has a Research Centre of Transport Engineering. According to a study by Wuhan University, Research Centre on the Evaluation of Chinese Science and Technology, North-western Polytechnical University is ranked number 18 among all Chinese universities in the field of Transport Engineering.

Xidian University is a key national university dedicated primarily to electronic engineering and information technology. It has around 30,000 students, including 8,100 master students and 1,700 doctoral students. There are about 1,800 full-time faculty members in the university. To date, the university has no dedicated research centre on automotive engineering. Nevertheless the expertise in electronics and electrical machine is helpful for research in automotive electronics, hybrid electric vehicles, and electric vehicles.

Xi'an University of Technology, founded in 1972, hosts about 15,000 undergraduates and 4,000 graduates. It has more than 2,000 faculty members, including approximate 160 professors and 371 associate professors. The university is strong in mechanical engineering. Up to date, there is no dedicated research centre on vehicle engineering or transport engineering.

Xi'an Institute of Optics and Precision Mechanics of China Academy of Science is one of the largest research institutes of China Academy of Science in the north-western area. The institute focuses on strategic high technology on optical devices and the applications. Recently it has made major contribution to the Chinese manned space program. The institute has about 700 full-time faculty members, half of whom are senior research fellows, including 19 doctoral supervisors, 50 research fellows, 90 associate research fellows and senior engineers. There are around 300 graduate students in the institute. Automobile is not the usual subject of the institute, but some technologies and devices developed by the institute may be applicable to automobiles.

Flight Automatic Control Research Institute was founded in 1960. FACRI has a staff of about 2,900, including more than 1,500 engineering technical personnel. FACRI is the Research & Development centre of guidance, navigation and control technologies in Chinese aviation industry. The institute is engaged in product design, development, production and after-sale service. Meanwhile, FACRI possesses two aeronautic key labs in flight and inertial technologies, and the key lab for vehicle integrated control technology. FACRI owns the right to grant the Master degree of 'precise apparatus and machine', and the master's and doctoral degree of 'navigation, guidance and control'. In the year 2001, after granted by National Ministry of Personnel, FACRI established the postdoctoral research station.

Xi'an Institute of Aeronautics Computing Technology is dedicated to the aeronautics software for on board and on-weapon embedded computers. It was founded in 1958 and has now 1046 personnel, including 781 technical personal. Among them, 157 persons have the senior title, 3 national experts, 10 provincial experts, 88 Master/PhD researchers. The institute has established collaboration with US Collins and British ULTRA in software development and testing.

Xi'an Research Institute of Micro-Electronics Technology is a member of Chinese Space Agency. The institute was founded in 1965 and concentrated in microprocessors, large scale integrated circuits for space and commercial applications.

Xi'an Aerospace Precision Electromechanical Institute was established in 1966. It is mainly engage in design, pilot production and batch production of various inertia instruments. It is a high tech enterprise integrating scientific research and production in inertia part industry in China Aviation, specializing in precision machinery, electronic circuit, electromagnetic element, precision tool and mold, and computer applications, etc. It is the organization at vice general director level under Chinese Society of Inertia Technology and the organization of recruit and train master degree candidates, and has obtained 120 scientific achievements at provincial and ministerial level and the Special Contribution Award for Complete Success of Manned Flight Shenzhou VI Spacecraft and Contribution Award for Manned Space Flight Project Shenzhou VII Spacecraft in 2005 and 2007, respectively.

Governmental and other public organizations

No.	Lead Organizations	Responsibility
13.	Xi'an Municipal Development & Reform Commission	Actively engaging national planning & policy, try to get state support
14.	Xi'an Science Technology Bureau	Enforcing and supporting national, provincial and municipal policies on science and technology; fundraising for research and innovation projects
15.	Xi'an Municipal Industry & Information Commission	Enforcing and supporting the policies and laws on industrialization and information technology. Supervising the innovation and technology advancement in industry
16.	Education Bureau of Xi'an	Supervising and supporting the education affair in Xi'an, including the universities
17.	Xi'an Association for International Exchange of Personnel	Attracting and helping foreign experts to work and live in Xi'an

Table 3: Overview of public organizations in Xi'an

Other organisations are: *Xi'an Software Organization* is an industrial organization of the software industry; *Xi'an Conference & Exhibition,* founded in 2002, is a non-profit organization for managing conferences and exhibitions in Xi'an; *Shaanxi E-Commerce Organization* is founded in 2011; *Xi'an Optical Electronics Organization* is a voluntary and non-profit organization of the industry, research institute, and universities in the field of optical electronics; *Xi'an Science and Technology Organization* was founded in 1958 and is a non-government and non-profit voluntary organization for promoting and disseminating science and technology.

Development agencies

High-tech and innovative corporations are concentrated in several special development zones. The total hi-tech industrial output value of these development zones accounts for approximately 90% of the total amount of the whole city. They are the power source for the sustainable and rapid development of Xi'an economy. Innovative companies also enjoy various kinds of benefits in these zones.

Xi'an Hi-Tech Industries Development Zone (XHTZ): XHTZ is among the first batch of national hi-tech development zones authorized by the State Council in March 1991. XHTZ has outstanding capability of independent innovation and rapidly developing scientific industries. Besides, it ranks the very front of the 54 national hi-tech development zones in terms of its integrated development index, thus becomes one of the six demonstration priority projects of hi-tech development zones to be built into the world first-class science and technology parks by the country. XHTZ is a new vigorous modern science and technology town with consummate public facilities of water, electricity, gas, heat, and communication, etc. The excellent environment of business initiation and innovation has enables XHTZ to attract a large group of excellent human resources to start businesses in the Zone, and to become the living and working place of first choice for top-notch talents. Job holders reach 400,000, including 48 academicians of the Two Academies (Chinese Academy of Sciences and Chinese Academy of Engineering), over 2,000 overseas scholars, over 4,000 doctors, and over 10,000 masters.

Xi'an Economic and Technological Development Zone: Located in the north of Xi'an City, Xi'an Economic & Technological Development Zone was established in 1993, and was approved to be a national economic and technological development zone in February 2000 by the State Council. In June 2002, the State-level Shaanxi Xi'an Export Processing Zone was established and located in north Xi'an. Comprising four functional parks of Central Area, Export Processing Centre, Jing-Wei Industrial Park, and Caotan Ecological Park, it aims at developing such four pillar industries as commercial vehicles, mechanism and electricity, food and beverage, and new materials. With evident advantages of location, convenient transportation, consummate supporting facilities and logistics support, excellent living environment and sound enterprise service system, over 2,500 enterprises have settled in it, including a large group of 500 Fortune as well as some famous international and domestic enterprises, such as Coca Cola, Siemens, ABB, Alstom, Mitsubishi, Hitachi, BP, Cummins, Hong Kong Investment Promotion Bureau, Taiwan Ting Hisin, Shenzhen Kingway, Shaanxi Heavy Truck, Sinosteel Xi'an Machinery, etc. As the most active and energetic area in terms of economic development in Xi'an, the proportion of the new development zones in the economic congregate of the whole city is becoming greater. On the basis of the favorable investment environment, the new development zones have become the base of the system innovation and the commercialization of research findings, and the window of opening-up to the outside world.

Xi'an Yanliang National Aviation Hi-tech Industrial Base: Xi'an Yanliang National Aviation Hi-tech Industrial Base is the only one which was approved by the State Development and Reform Commission on August 11, 2004, integrating the R&D of aviation industry, the training of aviation-based talents, aviation equipment manufacturing and integrated manufacturing, components processing and aviation-based services. The unique role was set up by the State because of the great aviation strength in Shaanxi Province. The Base focuses on the industries of integrated manufacturing, parts manufacturing, and aviation service, so as

to gradually form the industrial cluster with aircraft designing and manufacturing, and plane testing and appraising as the main body.

Xi'an National Civil Aerospace Industrial Base: Established in July 2006, Xi'an National Civil Aerospace Industrial Base was co-constructed by China Aerospace Science and Technology Corporation and both the Shaanxi Provincial People's Government and Xi'an Municipal People's Government. It enjoys municipal-level economic and managerial jurisdiction. The spaceflight industry was listed one of the five pillar industries which lead Xi'an's future development. Located in the southeast of Xi'an city, the Base has a planned area of 23.04km2 and a reserved planning space of about 20km2 for long-term development. It is blessed with favorable geographical advantages and convenient transportation being located at the axle wire of the city and connects bypass expressway, south third ring road, No. 2 Underground Line, and Xi-Kang Expressway. China Aerospace Science and Technology Corporation has reserved 40 aerospace projects to enter the Zone. Represented by the project of civil-use product initiated by No. 6 Research Academy of China Aerospace Science & Industry Corp. (CASIC), technical transformation projects of 7171 factory, five-billion solar PV projects, 1,500-ton silicon chip projects, and advanced semi-conductor power device projects of Northwest Constituent Company of China Power Investment Corporation, and industrialized base project of Northwest Industrial Technology Research Institute. In 2010, the sales revenue of Xi'an Aerospace Base will reach RMB 20 billion Yuan, taking in 100,000 jobholders, forming 10 to 20 famous-brand products with independent intellectual property rights and five to eight leading enterprises with comparatively strong competitiveness both inside and outside China, and becoming the independent innovation platform of aerospace technology, platform of civil-used industrial incubator, and the platform of cooperation among large international enterprises of West China. Efforts will be made to build it into the world famous national hi-tech industrial base.

Xi'an Chan-Ba Ecological District: Located at the eastern suburb of Xi'an, the district covers a total planned area of 129km2, including 89km2 for intensive treatment. Chan-Ba Ecological District will be ultimately transformed a new town of the third generation in Xi'an by centring on the construction of "four zones" (new urban zone, ecological zone, business zone and landscape zone) and "four belts" (ecological belt, landscape belt, tourism belt and economic belt). It is estimated that by year 2020, Chan-Ba Ecological District will be built into a new urban area that integrates multiple functions including ecology, business, landscape and residence. The construction of Chan-Ba Ecological District represents the strategic action taken by Xi'an Municipal Committee of CPC and Xi'an Municipal People's Government in carrying out the scientific outlook on development and the concepts of "four-modernization". It is also a key component for construction in the "11th Five-Year Plan" of Xi'an. It is of great significance to accelerate the construction of Chan-Ba Ecological District for improving the ecological environment of Xi'an, widening the urban development space, advancing the urban function and grade and quickening the development pace of Xi'an. As the most fashionable and modern emerging urban district that is characterized with vitality and outstanding ecological environment, Chan-Ba Ecological District is the very site where the Euro-Asia Economic Forum is held every two years and the exciting F1 Motorboat World Championship attracts great number of visitors. Besides, as the location for the first-ever "National Pilot District for the Protection and Restoration of Water Ecological System" and the "National Wetland Park" in West China, Chan-Ba Ecological District has become a sample for metropolitan ecological district in China. It is also the venue for the "China Cup" Ikebana Floriculture Contest and the 2011 World Horticultural Exposition. In year 2008, Shaanxi Provincial People's Government proposed to "build Chan-Ba Financial and Business

Zone and the key financial centre in West China", which ensured Chan-Ba Ecological District to grow into an important financial service centre in West China.

Xi'an International Logistics & Trade Park: As a significant node in China's logistics system and a key project defined in the "11th Five-Year Plan" of Shaanxi, Xi'an International Logistics & Trade Park is located nearby the permanent venue of the Euro-Asia Economic Forum, the venue of 2011 World Horticultural Exposition. The Park has a core area of about 19km2, planned expansion area about 33km2 and planned control area of 120km2.
Functioning as a specialized industrial park that focuses on modern logistics, modern trade and services, the Park, by relying on the two platforms including Xi'an Railway Container Central Station and Xi'an Comprehensive Bonded Zone, integrates the transport by highway, railway, airway and sea route as well as receives the businesses transferred from the coastal port into the hinterland. Therefore, the Park will forge the industrial clusters for trade, logistics, processing and services with speed, grow into the portal and bridge that links Northwest China with the Pearl River Delta Economic Circle, Yangtze River Delta Economic Circle and the Economic Circle Surrounding Bohai and finally turn into a logistics platform that renders services to Shaanxi, covers Northwest China and radiates to the nodal cities along the Eurasia Land Bridge. Located within the key strategic area for the development of Xi'an and endowed with premium locational advantage, the Park connects with the 3rd North Ring and the Bypass Expressway in the City, and is 5km away from the administrative centre of Xi'an. Here lie largest inland railway hub and one of the largest inland railway transport telecom centres in China. In addition, the Park is the centre of the radiating regional trunk railway network and the largest node in China's trunk highway network. Xi'an Xianyang International Airport, which is located nearby the Park, has been one of the seven largest airport hubs in China. Hence, endowed with advantageous location and convenient transport, the Park is bound to soar up in accelerated development.

Jingwei New City Commercial Automobile Industrial Park: The industrial park is under construction with the investment from a dedicated investment bureau of the Xi'an government. In the new park, the commercial automobile industrial cluster will come into shape, which is supported by finished automobile assembly and Cummins engine of the leading enterprise Shaanxi Automobile Group and supplemented by the spare parts enterprises, such as Hande, Deshi and Wanfang. Shaanxi Automobile Group is the fourth in China for the sale of heavy commercial automobiles. Its manufacture, design and research abilities are pioneering in China. The completed modern industrial manufacturing system, the strong machinery manufacture ability and spare parts manufacture ability are basically formed. The infrastructure, public resource allocation and habitation environment are gradually optimized. The function of the new park is gradually improved. In addition, the broad development space, outstanding transportation advantage and completed logistics supporting will strongly support the construction of the industrial park. The first investment for the construction is 1000 million RMB, and the total amount is virtually unlimited. The ultimate goal is to set this park as an automobile industry demonstration base and attract the automobile enterprises to establish industrial clusters in the park.

***Innovation platforms*[26]**

[26] Source: www.xibi.com

Xi'an Pioneering Park Development Centre (Xi'an High-tech Productivity Centre): The centre is directly managed by the management council of Xi'an Hi-Tech Industries Development Zone, and is a special organization for business incubation and commercialization. The centre was founded in 1993 and was approved as an national high-tech productivity centre. In May 1998, the centre built dedicated facility to support the start-up business of overseas Chinese scholars and experts and was approved by Chinese government as a national pioneering park development centre. The centre has incubated and supported more than 200 start-up companies and commercialized more than 1000 technologies.

Xi'an Overseas Chinese Scholars Pioneering Park: The park was founded in 1998 and is located inside Xi'an Hi-Tech Industries Development Zone. It is among the first batch of such pioneering parks approved by Chinese authority. To date, the park has hosted more than 830 overseas scholars from more than 20 countries like US, Japan, Canada, Australia, and many others in Europe. They have built more than 660 start-up companies in Xi'an.

*Xi'an Innovative University Students Pioneering and Job Hunting Service Centre***:** The centre was formally approved by the authority in 2004 to support the university students and is managed by Xi'an Pioneering Park Development Centre. The centre has dedicated facility to incubate the start-up business of university students.

*Mentor for Pioneering Business***:** The program is sponsored by Xi'an Pioneering Park Development Centre, aiming for consulting and supporting the new start-up business with expertise in administration, management, and legal issue.

- Support on patent application and IP protection: The Development Centre has negotiated with several agencies and legal consultancies to provide simplified procedure and all due support for patent application and IP protection.
- Fundraising: The Development Centre has professional financial platform to support the fund raising of medium and small scale enterprises. The platform integrates 14 banks, 4 trust companies, 4 small amount loan companies, 9 venture investment companies, 7 security companies, and 1 insurance company.

Xi'an College of High-Tech Enterprises: The College is dependent on Xi'an Pioneering Park Development Centre and aims to provide comprehensive educational and information services to the employees of high-tech enterprises.

2.4.3. Technology competence and economic ability of the cluster

Xi'an area is traditionally strong in aeronautics and aerospace related technologies. There are also a lot of large scale manufacturing factories in Xi'an area. Recently the city has put substantial effort and investment on automobile industry. With the establishment of Samsung's new chip manufacturing basis in Xi'an, the city will soon enjoy the leading position of IC and electronics competence in China. In recent years, the area has remained an important basis for aeronautics and aerospace. For example, many institutes and universities have contributed significantly in Chinese manned space program and new generation of airplanes.

The automotive industry has also made significant improvement recently. Shaanxi Automobile Group and Shaanxi Fast Auto Drive Group are among the top 20 automotive

corporations in China. Shaanxi Automobile Group has also innovative products on new energy vehicles.

Compared to more prosperous areas such as Beijing and Shanghai, Xi'an is certainly inferior in terms of business volume, financial availability, consumer capability, and so on, but being a less developed area it will enjoy larger increase rate in the future. Moreover the cost of human resource and facility is much cheaper than Beijing and Shanghai and there are abundant high-quality engineers and researchers in Xi'an thanks to the large number of universities and research institutes in the city.

Xi'an offers a suite of preferential policies for investment approved by Chinese government. Owing to its critical location in West China, Xi'an enjoys additional benefits entitled by West China Development program[27]. (1) Tax policies: Business can pay lower enterprise tax and tariff if it is located in Xi'an. (2) Foreign exchange control. Foreign exchange is usually not allowed in China. Business can enjoy certain freedom in Xi'an. (3) Land use: Business can temporarily have the ownership of certain land under relevant regulations.

Recently, Xi'an, together with other 15 cities, has been approved by the authority to start the program of building a low carbon transportation system. The goal is to reduce 10% fuel consumption and 11% CO2 emissions of all running vehicles. The fuel consumption and CO2 emission of public transportation vehicles will be reduced by 18% and 20% respectively.

2.4.4. Cluster organization management – technological focus and organizational capability

The major stakeholders for R&D activities in Xi'an can be categorized into 4 groups: universities, research institutes, innovative enterprises, and supporting government services.

All universities as listed above are directly managed by Chinese Ministry of Education and are administratively independent from Xi'an municipal and Shaanxi provincial governments. Nevertheless they keep tight collaboration with the local authorities, funding agencies, and enterprises for R&D projects, fundraising, recruiting new students, employment of graduates, etc. The universities play substantial roles on advancing the new technologies and innovation in Xi'an. Based on the agreement between the Chinese Ministry of Education and Shaanxi provincial government, a large amount of research and education funding comes from local budget. Therefore, the economic status of Xi'an and Shaanxi province crucially impacts the development of the universities.

Research institutes listed above are all directly managed by central ministries or Chinese Academy of Science. They are also not administratively independent of the local government. Similar as the universities, they also have tight collaboration with the business and people in Xi'an. Besides the funding and order from the national government, the institutes must fund themselves by selling services or products to the local market.

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[27] Source: www.xainvest.gov.cn/en/tzcb.asp

Enterprises are profit oriented. Since they are located in Xi'an, they are directly regulated by the local authority and must pay all types of taxes. To improve the competitiveness and profit, they actively seek innovations and new technologies, and this naturally binds them with the universities and institutes. Tight and successful collaborations are pervasive in both fundamental research and commercialization of new technologies.

The primary government service is Xi'an Pioneering Park Development Centre (Xi'an High-tech Productivity Centre). The centre is responsible for supporting start-up business, incubating emerging technologies, fundraising for R&D projects, etc. Other authoritative organizations listed in 2.3 decide the development plan, grand policies, priorities of different technologies and help on applying or allocating funding to the selected R&D projects.

2.4.5. Summary Xi'an

Xi'an area has remarkable capability of aeronautics and aerospace related technologies. There are also a lot of large scale manufacturing factories in Xi'an area. Recently the city has put substantial effort and investment on automobile industry and three automotive corporations are among the top 20 automotive corporations in China.

Located in centre China, Xi'an is less developed than Beijing and Shanghai in the economy aspect. On the other hand, as a less developed area, it will enjoy larger increase rate in the future. The cost of human resource and facility is much cheaper than Beijing and Shanghai and there are abundant high-quality engineers and researchers in Xi'an thanks to the large number of universities and research institutes in the city.

The format of research collaboration in this area is rather flexible. In the top-down approach, governmental agencies have annual and long-term research budget. The agencies will simply choose the best or the closely related universities or institutes to issue the funding. Alternatively, various call for proposals or competitions are organized to receive applications and choose the best candidate.

In the bottom-up approach, the universities, institutes, and companies may write proposals to public funding agencies or private venture capitalist. There are also much spontaneous collaboration between the companies and the universities, where dedicated projects are funded by both universities and the companies to solve jointly interested problems.

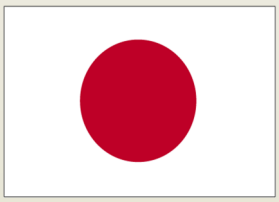
Financing of innovative projects are mostly the responsibility of government, e.g., Xi'an Pioneering Park Development Centre (Xi'an High-tech Productivity Centre). The large corporations may also share the responsibility depending on the potential of the projects.

The most important technological development area in Xi'an will still be manufacturing and aeronautics and aerospace. Automotive industry shares a lot of common technology basis with these strong fields and has a tremendous market in China and the world. Hence it is also a prioritized development area in the Xi'an area.

4. JAPAN

4.1. GENERAL INTRODUCTION

This chapter provides an overview of Japan in order to give a sense of the history, economy, cluster policies and automotive history. A more detailed description will be presented in the benchmark of the two regions chosen in the SAGE project Tokyo and Nagoya.



Japan at a glance:

Population: 127 million (67% live in urban areas)

Median Age: 45,4 years

Area: 377 915 km²

GDP: $4.497 trillion (2012)

Key industrial technologies: Among world's largest and technologically advanced producers of motor vehicles, electronic equipment, machine tools, steel and nonferrous metals, ships, chemicals, textiles and processed foods.

4.1.1. History

Japan forms a curved chain of islands located between the North Pacific Ocean and the Sea of Japan, east of the Korean Peninsula in the Eastern part of Asia. About 80% of Japan's land area is mountainous, with 60 active volcanoes, including the famous Mount Fuji, which rises to 3,776m over sea level. There is a big population concentration around Tokyo, where most government offices and company headquarters are located.
After its defeat in World War II, Japan recovered to become an economic power. Following three decades of unprecedented growth, Japan's economy experienced a major slowdown starting in the 1990s, but the country remains a major economic power. In March 2011,
Japan's strongest-ever earthquake, and an accompanying tsunami, devastated the northeast part of Honshu island, killing thousands and damaging several nuclear power plants. The catastrophe hobbled the country's economy and its energy infrastructure, and tested its ability to deal with humanitarian disasters.

4.1.2. Economy

Japan is the fourth largest economy after USA, China and India, if you count PPP (purchasing power parity) Japanese industry is a world leader in several sectors such as automotive, electronics and generally in production.

Most known abroad are the large companies whereas the small and medium-sized enterprises, which account for 70 % of jobs, are the backbone of the domestic economy. SMEs are suppliers of services, components, systems and specialized manufacturing.
For a Japan, poor in natural resources are growth through a focus on research and innovation high on the strategic agenda. Japan's research policy is kept together in the five-year Basic Science and Technology Plans with annual budget decisions. The current plan is the 4th Basic

Science and Technology Plan which runs from 2011 – 2015. The Plan advances five mid-to-long-term objectives aimed at making Japan a country that:

- Achieves sustainable growth and societal development, particularly the recovery and restoration of earthquake-damaged areas
- Realizes a safe and secure, high quality of life for its people
- Takes the initiative in solving global issues, including large-scale natural disasters. The public research is conducted at both universities and research institutes. Institutions sector is stronger than in for example Sweden. In principle, each Ministry has its own research institutes.
- Possesses a quality of S&T that undergirds national sustainability
- Continues to create "knowledge" assets and fosters S&T as culture.

Among the major OECD countries, Japan is the country that invests most in R&D. According to the Japanese Bureau of Statistics, Japan's total expenditure on R&D In 2010 was just above 17 trillion Yen, a decrease of 0.8 % from the previous fiscal year.

4.1.3. Cluster policy

The industry sector in Japan plays a leading role in research and innovation and major industrial stake holders conduct their research in-house, to a large extent. With regard to the academic side Japan is also strong with more than 750 universities of which almost 600 are privately operated.

4.1.4. Automotive sector

Japan is home to many large automotive companies e.g. Toyota, Honda, Daihatsu, Nissan, Suzuki, Mazda, Mitsubishi, Subaru, Isuzu, Kawasaki, Yamaha, and Mitsuoka. The country is the third largest vehicle manufacturer in the world after China and USA.
Less than 1% of automotive RTD in Japan is publicly funded. Most of the public funds are issued by the Ministry of Economy, Trade & Industry (METI) and supplied through the New Energy and Industrial Technology Development Organization (NEDO). Private investment contributes to a majority of automotive RTD spend.

4.1.5. National research bodies

JARI (Japan Automobile Research Institution)[28]

JARI is an independent and non-profit research organization, performs its mission as a public service corporation to contribute to healthy development of the automotive domain.
The research institute born in 1969 as Automobile High-Speed Proving Ground Foundation, and was subsequently reorganized into an organization to conduct comprehensive research on automobiles. It has since engaged in activities to develop the automobile industry and to advance automobile technology in Japan by performing neutral and public-benefit activities as a test-and-research organization and a public-service corporation that has the mission of contributing to sound progress of the automotive society.

[28] Source: http://www.jari.or.jp/english/

JARI is in charge of the cooperation with the automobile and related industries with a quite wide range of industries such as the energy, electric machinery, information, and communications industries. It promotes pioneering research to understand the future, and diffuse next-generation vehicles by fully utilizing the technology and knowledge.
The number of employees is around 400. The research institute is localised in Tsukuba (50km from Tokyo) and Shirosato area.

NEDO (New Energy and Industrial Technology Development Organization)[29]

The role of the NEDO is:

- Promotion of research and development of energy, environmental and industrial technologies as well as acquisition of emission reduction credits through the Kyoto Mechanisms.
- Development, demonstration and introduction of promising technologies that private sector enterprises cannot transfer to the practical application stage by themselves due to the high risk and long development period required.
- Efficient project management making the best use of the R&D capabilities and know-how of industry, academia and government.

AIST (National Institute of Advanced Industrial Science and Technology)[30]

AIST is a public research institution funded by the Japanese government. The present AIST is a rather new research organization established in 2001 regrouping 15 research institutes.
Headquarters of AIST are located in Tsukuba and Tokyo. AIST has over 40 autonomous research units in various innovative research fields, and the units are located at nine research bases and several sites (smaller than research bases) of AIST all over Japan. About 2400 researchers (about 2100 with tenure: about 80 from abroad) and thousands of visiting scientists, post-doctoral fellows, and students from home and abroad are working at AIST.

Main missions of AIST are competitiveness, local development and ecology of Japanese industry. Unlike other organizations, AIST occurs during the three phases of research (discovery, basic, and industrialization), enabling important exchanges between academics and industries.
AIST has defined three missions for its researchers:

- Advanced Research by exploring broad spectra of research fields and integrating multidisciplinary subjects to promote innovation in versatile fields that strengthen the competitiveness of Japanese industries in the world market and create new industries.
- Interdisciplinary and Cross-Disciplinary Research that enables planning long-range governmental policies by exploiting the current and future needs of society.
- Basic Research that maintains and strengthens competitiveness of national science and technology by developing and maintaining high standards of scientific and engineering research under the sole responsibility of AIST.

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[29] Source: http://www.nedo.go.jp/english/index.html
[30] Source: http://www.aist.go.jp/aist_e/about_aist/index.html

The Institute is involved in six research areas: energy and environment, biology, geology, meteorology, nanotechnology, electronics and computers, which must be added the interdisciplinary research. The institute employs 2500 researchers of various backgrounds and levels of expertise that carry out research with respect to the three main mission of the institute.

JST (Japan Science and Technology Agency)[31]

JST promotes science and technology to:

- Help to generate innovation based on science and technology, through the development of networks between academia and industry.
- Support development and activities of personnel who are to advance and deploy science and technology, while enhancing science communication between the public and S&T related professionals.
- Advance science and technology for sustainable development, while playing a role in Japan's leadership in the S&T field in the face of global society.

JSAE (Society of Automotive Engineers of Japan, Inc.)[32]

JSAE encourages the activities of various technology fields. The Technology Board establishes those committees composed of high level engineers and researchers from industry, academia and government who work to achieve solutions by carrying out investigations and research and by promoting activities geared toward the integration of automobile technologies. The results are widely disseminated throughout our members by means of symposia and reports. The Automotive Engineering Exposition: Started from 1992, the Automotive Engineering Exposition is an annual exhibit organized by JSAE. It is the only exhibition of its kind in Japan, where engineers and exhibitors at the cutting edge of automotive technologies can exchange information. It is the largest showcase for those who wish to cultivate new markets and customers in Japan.

NTSEL (National Traffic Safety and Environment Laboratory)[33]

The National Traffic Safety and Environment Laboratory are contributing to a safe and environmentally-friendly traffic society through activities in research and automobile type approval tests.

METI (Ministry of Economy, Trade and Industry)[34]

The Ministry of Economy, Trade and Industry (METI), is a ministry of the Government of Japan. It was created by the 2001 Central Government Reform when the Ministry of International Trade and Industry merged with agencies from other ministries related to economic activities, such as the Economic Planning Agency. METI has jurisdiction over a

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[31] Source: http://www.jst.go.jp/EN/index.htm
[32] Source: http://www.jsae.or.jp/index_e.php

[33] Source: http://www.ntsel.go.jp/e/index.html
[34] Source: http://www.meti.go.jp/policy/local_economy/tiikiinnovation/english.ver4.html

broad policy area, containing Japan's industrial/trade policies, energy security, etc. METI is known for its liberal atmosphere and officials of METI have been well known for their excellence.

4.2. TOKYO REGION

The following description of the regional research and innovation eco system within green and safe is provided by a representative from the SAGE partner's organizations and is carried out mainly through desk-top research from a distance.

4.2.1. Background information

The Greater Tokyo Area is a large metropolitan area in Kantō region. It includes the prefectures of Chiba, Kanagawa, Saitama, and Tokyo (at the centre).

A 2007 UN estimate puts the population at 35,7 million making it by far the world's most populous metropolitan area. It covers an area of approximately 13,500 km², giving it a population density of 2,642 person/km².

It is the second largest single metropolitan area in the world in terms of built-up or urban function landmass at 7,800 km². Only the New York metropolitan area, at 17,405 km², is larger.

Tokyo at a glance:

- **Population:** 36 million (13 million for Tokyo only)
- **Area:** 7 835 km²
- **GRDP:** approx. US$ 1191 billion (First world rank)
- **Major industry:** food, textiles and clothing, heavy industry, high technology (electronics, optics, cameras, etc.), mechanical engineering, chemicals, etc… Vehicle industry. Tokyo bay: the largest port area in the world (Tokyo port + Chiba port +Yakohama port + Kawasaki port

Figure 7: Location of the Tokyo region

***Transport infrastructure*:**

Air

The Greater Tokyo Area has two major airports, Tokyo International Airport, commonly known as Haneda Airport (chiefly domestic) and Narita International Airport (chiefly international).

Narita International Airport handles the majority of international passenger traffic to and from Japan, and is also a major connecting point for air traffic between Asia and the Americas. It handled around 62 million passengers in 2011. It is the fifth airport in the world.

Rail

Greater Tokyo has an extensive railway network comprising high-speed rail, commuter rails, subways, monorails, private lines, trams and others. There are around 136 individual rail lines in the Greater Tokyo Area, and around 1 100 railway stations, most designed for heavy use. (Tokyo Station has underground connections that stretch well over 4 kilometres, and Shinjuku Station has well over 200 exits). Greater Tokyo's Railway Network is the world's largest in terms of both daily passenger throughput with a daily trips of over 40 million (20 million different passengers).

Port

Greater Tokyo includes 4 ports: Tokyo, port of Chiba, Yokohama and Kawasaki. Their activities make Tokyo Bay the largest industrial port complex in the world in terms of total volume traded.

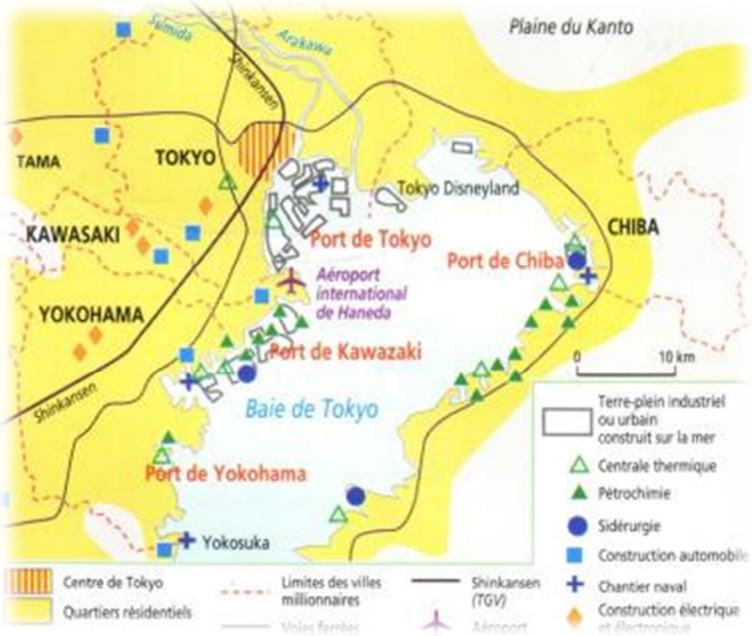

Figure 8: Tokyo port area

Due to technological innovations and the introduction of new industries and technologies in the 1960s, this period saw the beginning of mass production of synthetic fibres and household electric appliances such as televisions, refrigerators, and washing machines. As a result, the everyday lives of the residents of Tokyo underwent considerable transformation. In 1962 the population of Tokyo broke the 10 million mark. In 1964 the Olympic Games were held in Tokyo, the Shinkansen ("Bullet Train") line began operations, and the Metropolitan Expressway was opened, forming the foundation for Tokyo's current prosperity.

Competitiveness and Economy

The area has the largest metropolitan economy in the world, with a total GDP of approximately US$1900 billion in 2008. The agglomeration of Tokyo had a total GDP of US$1479 billion in 2008 (at purchasing power parity), ranking again as the largest urban agglomeration GDP in the world.

In the 1980s, Tokyo took large steps in economic growth as a result of its increasingly global economic activity and the emergence of the information society. Tokyo became one of the world's most active major cities, boasting attractions such as cutting-edge technology, information, culture, and fashion, as well as a high level of public safety. From 1986 onwards, land and stock prices spiralled upwards, a phenomenon known as the "bubble economy."

Japan enjoyed tremendous growth under the bubble economy, but with the burst of the bubble at the beginning of the 1990s, sinking tax revenues caused by the protracted economic slump led to a critical state in metropolitan finances. Tokyo was, however, able to overcome this financial crisis through two successive fiscal reconstruction programs.

Tokyo is now accelerating efforts to achieve the goals of the 10-Year Plan, Tokyo's urban strategy formulated in 2006. Along with such endeavours, a new vision for the city, Tokyo Vision 2020 was formulated to deal with new challenges such as those that came to light with the Great East Japan Earthquake of March 2011. While using this as a new blueprint to drive change for the revitalization of Japan, Tokyo will continue to evolve into a city that befits the 21st century.

Tokyo and its suburbs is the main financial, industrial and commercial centre in Japan. Industrial activities are much diversified: food, textiles and clothing, heavy industry, high technology (electronics, optics, cameras, etc.), mechanical engineering, chemicals, etc. - Are concentrated along the shores of Tokyo Bay forming a huge industrial area. This complex provides a fifth of the national industrial output value. Heavy industry is predominant: oil refinery, steel industry.
The city hosts 47 of the Fortune Global 500 companies, the highest amount of any city. Tokyo has the largest city economy in the world and is one of three command centres along with New York City and London.

Automotive history in Japan

Cars built in Japan before World War II tended to be based on European or American models. Between 1925 and 1936, the United States Big Three automakers' Japanese subsidiaries (Ford, GM, Chrysler) produced a total of 208 967 vehicles, compared to the domestic producers total of 12 127 vehicles. In 1936, the Japanese government passed the Automobile Manufacturing Industry Law, which was intended to promote the domestic auto industry and reduce foreign competition.

In 1939, the foreign manufacturers had been forced out of Japan. Vehicle production was shifted in the late 1930s to truck production due to the Second Sino-Japanese War. For the first decade after World War II, auto production was limited, and until 1966 most production consisted of trucks. Thereafter passenger cars dominated the market. Japanese car designs also continued to imitate or be derived from European and American designs. During the 1960s, Japanese automakers launched a bevy of new "kei" cars in their domestic market; scooters and motorcycles remained dominant, with sales of 1.47 million in 1960 versus a mere 36,000 kei cars. These tiny automobiles usually featured very small engines (under 360cc, but were sometimes fitted with engines of up to 600cc for export) to keep taxes much lower than larger cars. The average person in Japan was now able to afford an automobile, which boosted sales dramatically and jumpstarted the auto industry toward becoming what it is today.

By the end of the sixties, these (often two-stroke) cars, were being replaced by full one-litre cars with four-stroke engines. Rapidly increasing domestic demand and the expansion of Japanese car companies into foreign markets in the 1970s further accelerated growth. Passenger car exports rose from 100,000 in 1965 to 1,827,000 in 1975. Automobile production in Japan continued to increase rapidly after the 1970s, as Mitsubishi (as Dodge vehicles) and Honda began selling their vehicles in the US. Even more brands came to America and abroad during the 1970s, and by the 1980s, the Japanese manufacturers were gaining a major foothold in the US and world markets. With Japanese manufacturers producing very affordable, reliable, and popular cars throughout the 1990s, Japan became the largest car producing nation in the world in 2000. However, its market share has decreased slightly in recent years, particularly due to old and new competition from South Korea, China and India. In 2011, the Tsunami disaster made many automakers and suppliers forced to stop or reduce production in the North East region. In the auto sector, consisting of supply chains of companies from many layers and fields, the lack of just one part or component had a serious impact on the automobile industry as a whole. In 2012, Automobiles are the focus of an extremely wide range of industrial and related activity, from materials supply and vehicle production and distribution to sales, servicing and other auto-centred operations. Auto-related employment in Japan at present totals 5.32 million people (8.5% of Japanese workforce).

There are historically two kinds of automotive companies in Japan. The first type is that a big company has created an automotive company such as Nissan and Mitsubishi Motors. Mitsubishi Motors has been established from the Mitsubishi Heavy Industry.

The second type is that a local company has created an automotive company such as Toyota, Honda, Suzuki and Mazda.

According to the history of the company, the relation between automotive company and the region is different. For instance, at present, Nissan Motor has it's headquarter at Yokohama, and R&D is located in Kanagawa Prefecture and manufacturing plants are located in Kanto area and Kyushu area. The Tokyo region is not suitable as manufacturing plant due to the high ground cost and any influence to neighbouring residents. So, Kyushu area is selected as one of manufacturing plant location, further Kyushu area is near the China. Therefore, the location is suitable to the China market from the logistics standpoint.

Regarding the 2nd type automotive company, the example of Toyota Motor Corporation is explained. In the Meiji era, Mr Sakichi Toyoda, who is called as one of the ten greatest inventors in Japan, invented many power loom and obtained many patents in Japan and overseas countries during managing Toyota Industrial Company in Aichi Prefecture (Nagoya Region). On the occasion that the overseas patents were assigned to the UK Company and Mr Toyoda obtained huge amount patent assignment expense, Mr Sakichi Toyoda instructed his son, Mr Kiichiro Toyoda to establish new automotive company (Toyota Motor Corporation) in the city of Toyota. Thereafter, although Toyota Motor Corporation faced the great economic difficulty, the new development and improvement have been continually conducted. The automotive industry needs many suppliers to assemble the car as the final product. In the Nagoya region, there are many companies located firstly as the textile industry. These companies have been converted to the automotive suppliers in these areas. Nowadays, the automotive industry is so crowded in this area. So, in order to reduce the risk management, Toyota has decided to construct new manufacturing plants in Kyushu and Tohoku (Northern part of Honshu), further achieving the low operating costs.

In Nagoya region, ceramics industry companies are also accumulated, including Noritake, NGK Insulators, and so on. In Europe, cars installed with diesel engine are popular, and the

diesel engine may also be equipped with the diesel particulate converter for purification purpose. These converters manufacture in this region are supplied to EU automotive companies

4.2.2. Regional innovation system

This chapter describes the various players of the cluster and regional systems to support innovation.

Public Policies for Industrial Cluster Development:

The Japanese government has established "framework plans" for the development of science and technology by combining academic research policy with industrial development policy since the year 2000. As a result, university spending on scientific research has been increasing rapidly and university-industry partnerships as well as regional research interactions have been growing steadily for the last few years. At the same time, METI (The Ministry of Economy, Trade and Industry) has adopted a new policy of cluster development to reinforce the dynamics of industrial networks involving universities, businesses and governments in clusters since 2001.

In the Tokyo metropolitan area, there are two sector-based clusters supported by METI:

- One is the cluster of IT and content industries in the greater Tokyo region, networking 290 companies, Keio University and five local government offices, where the key sectors include film production, gaming, online entertainment and publishing.

- The other is a biotechnology cluster, based on the "bio" network of Yokohama, Chiba, Tsukuba and central Tokyo, where the Bio Industry Association of Japan is promoting various bio businesses in collaboration with METI.

Industry

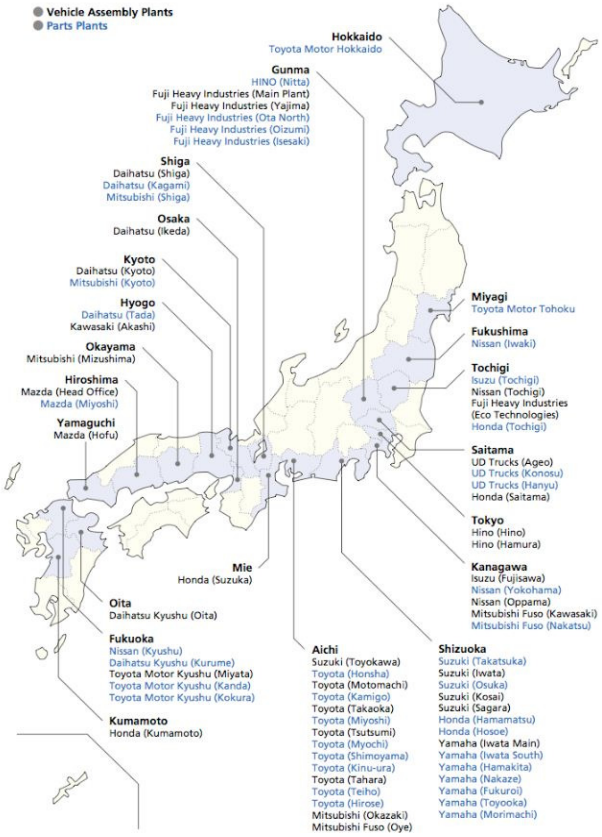

Figure 9: Automotive Industry locations in Japan

Tokyo region is not a region with a big industrial concentration in the automotive sector contrary to Aichi (Toyota), Kyushu (Fukuoka-Kitakyūshū) and Hiroshima (Mazda) and to a lesser extent Kanagawa (Nissan), Saitama (Honda) and Shizuoka (Suzuki)

The particularity of Japanese automotive industry is that big car manufacturers don't work together on main subjects and even don't share suppliers. Each of them has its own ecosystem, with factories, research centres and suppliers. The collaboration between Japanese car manufacturers is found especially in the JARI on specific themes (electric, hybrid, fuel cell). Some universities (Waseda, Hiroshima, and Kyoto) are working on automotive topics but the main part of R&D is done internally by each manufacturer. In Tokyo region are located two main companies: Nissan motor and Hino.

Nissan Motor[35]

Nissan Motor Company is a multinational automaker headquartered in Japan. It was a core member of the Nissan Group, but has become more independent after its restructuring under Carlos Ghosn (CEO). Nissan was the sixth largest automaker in the world behind Toyota, General Motors, Volkswagen AG, Hyundai Motor Group, and Ford in 2010. It formerly

[35] Source: http://www.nissan-global.com/EN/index.html; http://www.nissan.co.jp/EN/index.html

marketed vehicles under the "Datsun" brand name. In 1999, Nissan entered a two way alliance with Renault S.A. of France, which owns 43.4% of Nissan while Nissan holds 15% of Renault shares, as of 2008. Along with its normal range of models, Nissan also produces a range of luxury models branded as Infiniti. In 2011, the company's global headquarters is located in Nishi-ku, Yokohama. The main research centre is also located in greater Tokyo area. Nissan employees are around 155 099 in 2011.

Hino[36]
Hino Motors, Ltd. is a manufacturer of diesel trucks, buses, and other vehicles, based in Hino, in greater Tokyo area. Since 1973 the company has been the leading producer of medium and heavy-duty diesel trucks in Japan. It is a subsidiary of Toyota Motor Corporation. Hino employees are around 155 199 in 2011.

Other companies located in Greater Tokyo Area:
Isuzu, Mitsubishi Motors, Honda, Subaru (Fuji Heavy Industries), UD Trucks and Denso.

Universities and research institutes

The University of Tokyo and its Institute of Industrial Sciences (IIS)[37]

The University of Tokyo, also known as "Todai" was established in 1877 as the first national university in Japan. The University currently comprises 10 faculties, 11 institutes, 15 graduate schools, and a number of shared facilities. The Institute of Industrial Science (IIS) is the largest of these institutes; currently, the IIS comprises five research departments, one guest chair, four endowed chairs, eight research centres, three collaborative research centres and one international collaborative research centre.

At the IIS, extensive research ranging from basic to apply in a wide variety of engineering fields is conducted across approximately 160 laboratories, which are primarily led by professors, associate professors, and lecturers. Each of the laboratories is affiliated to one of the five departments or eight research centres. Research activities include both innovative research based on the original ideas of researchers and the dissemination of the obtained results throughout the society. The research of the IIS ranges widely from basic engineering to applied technology; therefore, it is essential to promote research and development in cooperation with industry. For this purpose, cooperative research with private sector and funded research are conducted, and further contacts and exchanges with researchers in private sectors are promoted. Furthermore, endowments from the private sectors have enabled to establish and maintain endowed chairs, to which project professors and project associate professors from outside are appointed. Thus, as a university affiliated research institute open to society, IIS makes every effort to promote engineering research and to make use of research results to contribute to society.

Waseda University[38]

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[36] Source: http://www.hino.com/
[37] Source: http://www.iis.u-tokyo.ac.jp/index_e.html

[38] Source: http://www.waseda.jp/top/index-e.html

Waseda University is a private Japanese university, located in Tokyo. Its main campuses are located in the northern part of the district of Shinjuku. The university has over 53 000 students, including 8 700 in higher education (postgraduate).

The Mobility Lab of Waseda University has an R&D activity over the entire chain of electric vehicles, from the technologies used to the vehicles themselves:

- Electric Microbus with the development of several generations of prototype WEB (Waseda advanced Electric Micro Bus): Experiments in Nara and Nagano with charging by induction, and the development of a solar station
- Parallel hybrid vehicles with range extender
- Fuel Cell Vehicles: an experimental car has been developed and several prototypes of quadricycles of trucks or vehicles for special uses.

On technologies, Waseda works on various lines of research:

- Loading devices: charging by induction, battery exchange, fast connection ...
- Electric motors, especially new technologies for permanent magnet synchronous motors
- Lithium-Ion Batteries with studies on behaviour and R & D on new generations of Lithium Iron Phosphate batteries suitable for quick charge and the development of novel compounds for a recharge to 8 or 10°C.

Governmental and other public organizations

TOKYO-CCI (The Tokyo Chamber of Commerce and Industry)

TCCI was established based on the need to shape business opinions. TCCI is active in voicing recommendations to the Diet, the Tokyo Metropolitan Government, and other government agencies, so that companies are able to maintain vitality and facilitate successful management in an era of ceaseless change. The voices of TCCI members lead to positive social changes in Tokyo and throughout Japan. Addressing the concerns of SME management: Small and medium-sized enterprises play a critical role in Japan's economic development, accounting for 99.7% of Japanese companies and around 70% of domestic jobs. TCCI works tirelessly to strengthen SME management and to support the drive for continued growth, providing numerous membership services.

4.2.3. Technology competence & economic ability of the cluster

Automotive stakeholders (Industrials and academics) in the area are actively involved in 2 main strategic developments[39]:

- Intelligent Transportation Systems: Connected Vehicle (V2I / V2V Communication), Automated Vehicles, Collaborative driving systems, Advanced Driver Assistance Systems (ADAS), etc.

[39] http://www.jama-english.jp/index.html

- Electrification of the vehicle: Mechatronics systems and Power Electronics, Energy storage systems and energy management, Charging systems, etc.

4.2.4. Cluster organization & management – technological focus organizational capability

In Japan, the industry sector plays the leading role in the R&D innovation. The academic sector leads the academic- industrial alliance projects from a neutral place. The government can support the accomplishment of the projects by subsidies[40].

The benefits are as follows;

- Industry sector: Business development
- Academia sector: Research papers and education
- Government sector: Policy accomplishment

4.2.5. Summary Tokyo

The Greater Tokyo area concentrates more than 25% of Japanese population. The city capital is the decision centre of the country and home of the major companies' headquarters. Tokyo has the largest metropolitan economy in the world based on the industrial and services sector: finance, tourism, automobile, electronic, chemical, heavy industries.

The region has excellent universities and public laboratories but no big industrial concentration in the automotive sector compare to other Japanese regions (Aichi, Kyushu, Hiroshima...). The industry sector plays the leading role in the R&D innovation private investment contributes to majority of automotive R&D spend, but the vertical organization doesn't facilitate large interactions.

It is difficult to identify a real automotive cluster in the region. There is no cluster organization or particular cluster policy. Triple helix is not very active and cooperation is mainly bilateral (direct link between one OEM and a university or one OEM with its suppliers).

With key competences in electronics and IT, the Greater Tokyo area has indisputable strengths for the development of Safe and Green road vehicles. But it may be difficult to build international collaboration due to the lack of automotive cluster organization and the long time needed to create partnership relations.

[40] http://www.glocom.org/opinions/essays/20070717_cavasin_industrial/index.html
http://www.tokyo-cci.or.jp/english/

4.3. NAGOYA REGION

The following description of the regional research and innovation eco system within green and safe is provided by a representative from the SAGE partner organizations and is done from a distance.

4.3.1. Background information

Nagoya is the largest city in the Chūbu region of Japan. It is the third-largest incorporated city and the fourth most populous urban area in Japan. Located on the Pacific coast on central Honshu (Figure 10); it is the capital of Aichi Prefecture and is one of Japan's major ports. It is also the centre of Japan's third largest metropolitan region, known as the Chūkyō Metropolitan Area. As of 2000, Chūkyō Metropolitan Area has 8.74 million people, of which 2.27 million live in the city of Nagoya.

Figure 10: Location of Nagoya region

Nagoya at a glance:

- **Population:** 2 261 377 inhabitants (1 April 2012)
- **Area:** 326,45 km²
- **GRDP:** Greater Nagoya 459 billion USD. Accounts for about 1% of world GDP
- **Major industry:** Automotive, aerospace and ceramic industries are the main industries in the Nagoya region. Nagoya is also the hub of Japanese manufacturing industries, producing over 40% of major manufacturing categories such as automobiles, automobile parts, machine tools and aircraft parts.

Transport and infrastructure[41]

Air
Greater Nagoya is served by two major airports: Central Japan International Airport (Centrair), which is one of Japan's most convenient; and Nagoya Airport, which also handles smaller aircraft such as business jets.

Rail:
Utilizing the Shinkansen bullet train from Greater Nagoya, executives can easily travel to Tokyo (95 minutes) or Osaka (52 minutes) for business meetings and return on the same day.

[41]Source: http://greaternagoya.org/

Highway:
The area around Nagoya has been a crossroad since ancient times, with its advanced expressway network. The Tomei Expressway allows access to Tokyo in four hours and the Meishin Expressway reaches Osaka in 2 hours.

Port:
The Port of Nagoya ranks no. 1 in export shipping, both in volume and value[42]. In addition, the Port of Mikawa is well-known for handling automobiles, and the Port of Yokkaichi is active in trade with China and Southeast Asia.

Competitiveness and Economy

Automotive, aerospace and ceramic industries are the main industries in the Nagoya region. Many automotive players have their presence in the Nagoya region. Lexus has it's headquarter in this region. Mitsubishi Motors have R&D headquarters in Okazaki located in the suburbs of the Nagoya. It also hosts automotive suppliers like DENSO, Aisin Seiki, Toyota Industries, Toyota Boshoku, Aerospace-related firms operating in Nagoya include Boeing, Pratt & Whitney, Mitsubishi Heavy Industries, Bodycote, Kawasaki Heavy Industries and Fuji Heavy Industries.

Many automotive companies are based out of Nagoya region.

- Transportation machinery tools manufacturing: 4,993 million yen
- Electronics parts and devices manufacturing: 111 million yen
- Information and communications machinery and equipment manufacturing: 212 million yen (Ministry of Economy, Trade and Industry, Census of Manufacturers 2008)

The City of Nagoya has set a unique target to decrease CO2 and greenhouse gas emissions by 10%. In order to preserve limited natural resources, help prevent global warming, and create a better living environment for future generations, the city calls on its 2.2 million residents, already successful in previous garbage-reduction efforts, to challenge themselves "ONE MORE TIME!", and work together with business and government to promote more environmentally-friendly lifestyles.

National context

[42] Source: http://greaternagoya.org/

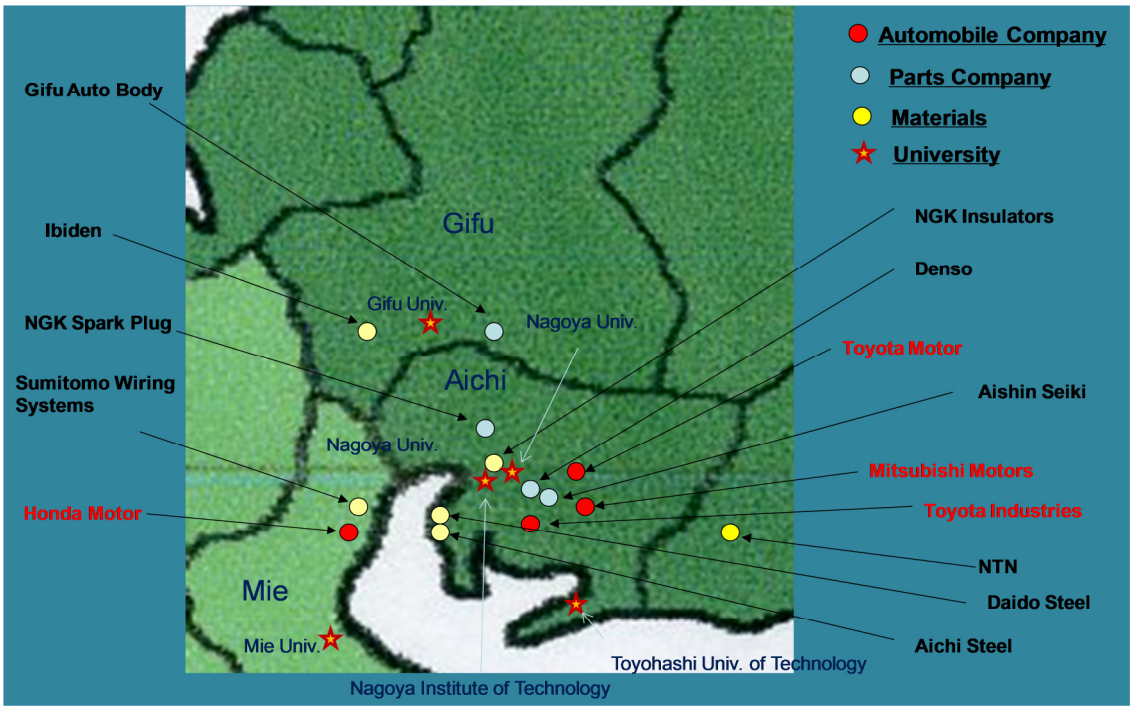

Figure 11: Overview of companies and universities in the Nagoya region

4.3.2. Regional innovation system

This chapter describes the various players of the cluster and regional systems to support innovation.

Greater Nagoya Initiative Centre[43] (GNIC) established in February, 2006, a joint organization of national government, local governments, industries and academia, was created to promote foreign direct investment and alliance between overseas and Japanese companies. In cooperation with affiliated organizations, GNIC provides "one-stop" services to overseas corporations interested in starting or expanding business into Greater Nagoya. Such complimentary services for overseas businesses include providing information on the region, research, public information and advertising, invitations, matching up with appropriate corporations and assistance for business start-ups.

Industry

Greater Nagoya boasts one of the world's great clusters of automotive companies. World-renowned automakers such as Toyota, Honda, Suzuki, Mitsubishi, Volkswagen, and General Motors have headquarters, major manufacturing operations, or distribution points in the region. In fact, 44% of the automobiles produced in Japan come from Greater Nagoya.

Toyota Motors Corporation[44]
Toyota is a multinational automaker headquartered in Toyota, Aichi, Japan. It is the largest automaker in the world by 2010 and 9th largest corporation in the world by revenue.

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[43] Source: http://greaternagoya.org/
[44] Source: http://www.toyota-global.com/

Toyota is one of the largest companies to push hybrid vehicles in the market and the first to commercially mass-produce and sell such vehicles. Worldwide sales of hybrid vehicles produced by Toyota reached 1.0 million vehicles by May 31, 2007, and the 2.0 million mark was reached by August 31, 2009, with hybrids sold in 50 countries.
Toyota is currently testing its "Toyota Plug-in HV" in Japan (commercialized), the United States, and Europe. Toyota is speeding up the development of vehicles that run only on electricity with the aim of mass-producing them in the early part of this decade. Road tests for the current prototype, called "e-com", had ended in 2006. Toyota has made many concept electric vehicles, including the FT-EV and FT-EV II.

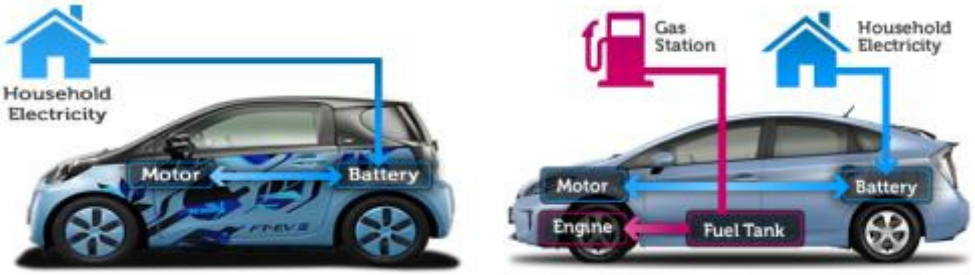

Figure 12

Mitsubishi Motors[45]
Mitsubishi motors corporation (MMC) is devoting significant resources to the development of such zero-emission cars. And in the meantime, MMC continues to focus on reducing CO2 emissions by raising powertrain efficiencies, improving its gasoline engines and mating them with CVTs. MMC's electric vehicles are sold as the name of i-MiEV.
MMC takes an all-inclusive approach to the environmental impact of the car through all its life stages, including manufacture, use and collection. This includes the development and use of structures and materials that facilitate end-of-life disassembly, recycling and reuse.

Figure 13: Nagoya auto cluster and various industries

Automotive industry - Company names

1 TOYOTA MOTOR Head office

[45] Source: http://www.mitsubishi-motors.com/

2 TOYOTA MOTOR Motomachi plant
3 TOYOTA MOTOR Takaoka plant
4 TOYOTA MOTOR Tsutsumi plant
5 TOYOTA MOTOR Tahara plant
6, HONDA MOTOR Suzuka factory
7 MITSUBISHI MOTORS Nagoya plant
8 SUZUKI MOTOR Toyokawa plant
9 TOYOTA INDUSTRIES Nagakusa plant
10 TOYOTA INDUSTRIES Takahama plant
11 TOYOTA BOSHOKU Headquarters
12 TOYOTA Auto Body Head office
13 TOYOTA Auto Body Inabe plant
14 AISAN INDUSTRY Head office
15 DENSO Headquarters
16 AISIN SEIKI Head office
17 AISIN AW Head office
18 NGK INSULATORS Head office
19 KAYABA MANUFACTURING Gifu South plant & Gifu North plant
20 TENRYU INDSUTRIES Head office
21 TOKAI RIKA Head office
22 FUTABA INDUSTRIAL Head office
23 SANGO Head office
24 MITSUBISHI HEAVY INDUSTRIES Nagoya aerospace systems works
25 MITSUBISHI HEAVY INDUSTRIES Nagoya guidance & propulsion systems works
26 KAWASAKI HEAVY INDUSTRIES Gifu works
27 FUJI HEAVY INDUSTRIES Handa plant
28 NIPPON SHARYO Toyokawa plant

Universities and research institutes

Nagoya University[46]

Nagoya University began its history in 1871. In 1939, the Nagoya Imperial University was established with the addition of the School of Science and Engineering and the School of Medicine. In 1942, the School of Science and Engineering was divided into the School of Engineering and the School of Science, and the name of the university was changed to Nagoya University in 1947. Currently, there are 13 graduate schools. Other facilities include 3 subsidiary research institutes, 2 facilities open to the public and 16 research centres. It hosts to 9758 undergraduate students, 6190 post graduate students and has around 3223 staff in 2011.

Section	Number	Proportion
Life Science	289	27.58%
Information-Communication	90	8.59%
Environment	135	12.88%

[46] Source: http://www.nagoya-u.ac.jp/en/

Nanotechnology / Material	281	26.81%
Energy	53	5.06%
Manufacturing Technology	165	15.74%
Infrastructure	26	2.48%
Frontier	9	0.86%
Total	1,048	100.00%

Table 4: Trend in research projects by industry FY 2010

FY2006	372	4,436,000,000
FY2007	398	4,977,000,000
FY2009	391	5,624,000,000
FY2009	469	4,884,000,000
FY2010	461	5,594,000,000

Table 5: Trend in Public funding received by Nagoya university

Toyohashi University of Technology[47]

Founded in 1974, Toyohashi University has 1147 Undergraduate Course Students, 919 masters student and 121 doctoral students. It runs courses in majority of engineering disciplines. Toyohashi University of Technology: Research centre for future vehicle city.

The Research Centre for Future Vehicle City was renewed on April 2011. The project of 2nd phase of the renewed research centre is financially supported by Ministry of Education, Culture, Sports, Science and Technology.

The Research Centre for Future Vehicle City has established two research divisions: "low-carbon society and advancement of Industry" and "low-carbon society, safety and security". The former is composed of fields of natural energy, logistics, environment, urban system. The latter is composed of fields of safe and secures natural energy, and environment.

Following pictures are some of the demonstrative projects of research work:

Figure 14: Demonstration projects within Toyohashi University of Technology

[47] Source: http://www.tut.ac.jp/english/

Gifu University[48] is in the city of Gifu. It was founded in 1943.It offers education in the area of medicine, engineering study, biological science, agriculture. The university has strength of 830 faculties, 5751 undergraduate and 1691 graduate and 72 doctoral students. Gifu University has dedicated research centre in various areas like Centre for Advanced Die Engineering and Technology and Centre for innovative photovoltaic systems. It is also a collaborator of Nagoya Green Mobility Collaborative Research Centre. It received almost 1, 35,771 thousand yen investment in industry academia research collaboration projects. University files almost 26 patents on average annually.

Mie University[49] was established on 31st May 1949. Around 6150 undergraduate students and 1239 graduate students are enrolled in the university. University has faculty strength of 762.It offers undergraduate and research in the area of engineering, life science and humanities.

Nagoya Institute of Technology (NIT)[50] founded in 1905, is a public highest-level educational institution of science and technology located in Nagoya, Japan. It has around 4050 under graduate, 1297 masters' student and 244 doctoral students. NIT remains committed to advancing social development through the pursuit of creative research projects and development of talented researchers. In response to social demands, it is proactively involved in collaborative research.

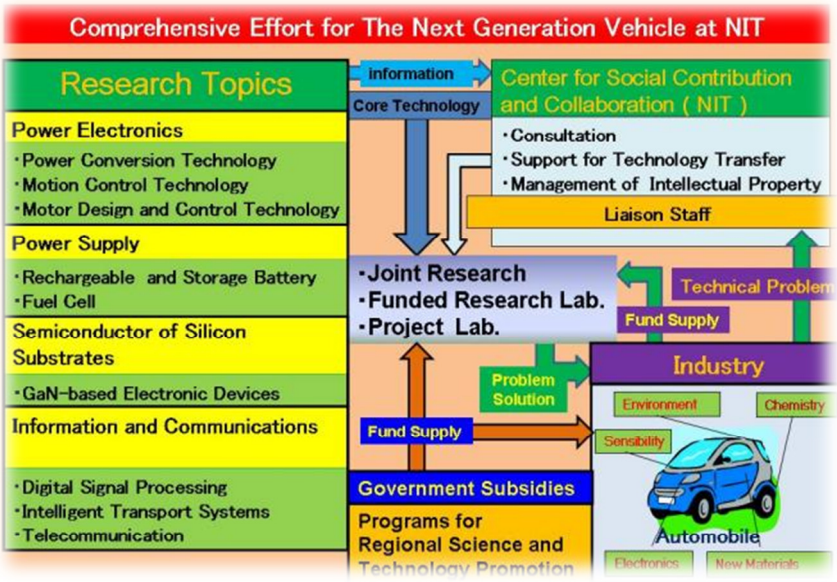

Figure 15: Nagoya institute of Technology collaboaration model

Governmental and other public organizations

Public R&D organizations such as the National Institute of Advanced Industrial Science and Technology (AIST) and Nagoya Institute of Technology cooperate with academia and business on research projects and development of resources for industry. These organizations

[48] Source: http://www.gifu-u.ac.jp/english/
[49] Source: http://www.mie-u.ac.jp/en/
[50] Source: http://www.nitech.ac.jp/eng/

belong to the GNI Partners Club and work hand-in-glove with corporations on research projects.

AIST
The national institute of Advanced Industrial Science and Technology (AIST), led by President Nomakuchi, is a public research institution funded by the Japanese government to a large extent, see 4.1.5 and holds Chubu Center as local base. .

Aichi Centre for Industry and Science Technology[51]
The centre has its foundations right in 1927 and it has evolved through various centres. According to service needs they offer services in the area of Research and Development, testing, consultation and technology transfer.
They provide technical support in the field of industrial technology, targeting a wide range of the flourishing manufacturing industries of Aichi Prefecture including machinery, metals, plastics, and lumber. Centre researches, develops and evaluates a variety of technologies such as organic and inorganic chemicals, metal and surface treatment technologies, wood material and logistics technologies, bio- and nanotech, machine technology, and next generation batteries, and strive to promote the widespread dissemination of our results. In addition, we are also engaged in providing local businesses with general technical consultation and technical information.

Automobile and Mechanical Technology Group

- Conducts research on difficult-to-process materials, teaching robots, and fuel cells.
- Develops and evaluates next-generation battery parts, including fuel cells.
- Hosts technical lectures on next-generation automobiles and study sessions for aerospace engineers.

Innovation platforms

METI Program is sponsored by Chubu Bureau of Ministry of Economy, Trade & Industry. It has aimed for "Forum on the Future Automobile Development". It works on the areas like strengthening the coordination between the industry and academia, establishing the committee for next generation projects in materials, battery and IT systems.

MEXT Program is sponsored by Ministry of Education, Culture, Sports, Science & Technology. It is a Collaboration Scheme proposal to the Industry-Academia R&D for Future Automobile development.

[51] Source: http://www.aichi-inst.jp/en/

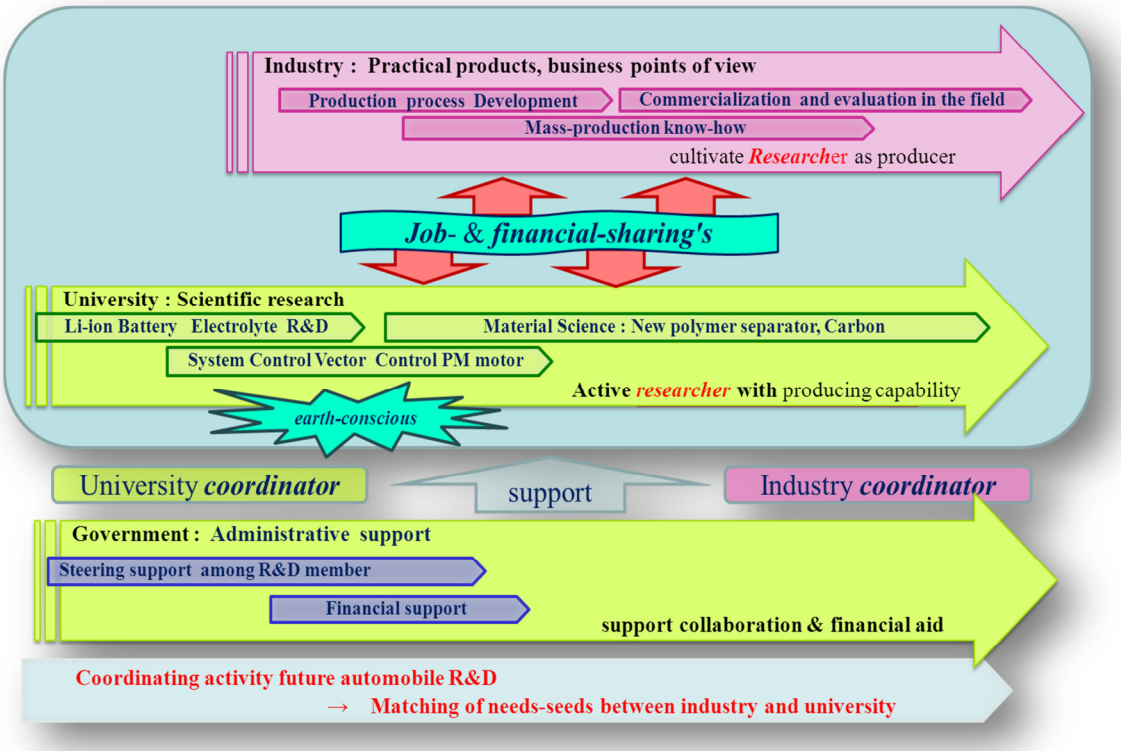

Figure 16: Example of industry academia government collaboration

Green Mobility Collaborative Research Centre (GreMo)[52]

The Nagoya University: school of engineering and Eco Topia Science Institute currently from the core of activities at Nagoya University. These organizations received recognition as innovation centre establishment assistance program in 2009. The departments have a track record in research within the area of green mobility.

The work in research focuses on the areas outlined for innovation much in demand from industry, local authorities, universities and research organizations**.** Centre has agenda to develop research and development and human resource by 2016 through external partnership. GreMo had a budget of 1 billion Yen / year in 2011.

For 2011, automotive mechatronics, energy and environmental studies, next generation batteries and ITS was the research focus.

[52] Source: http://www.gvm.nagoya-u.ac.jp/

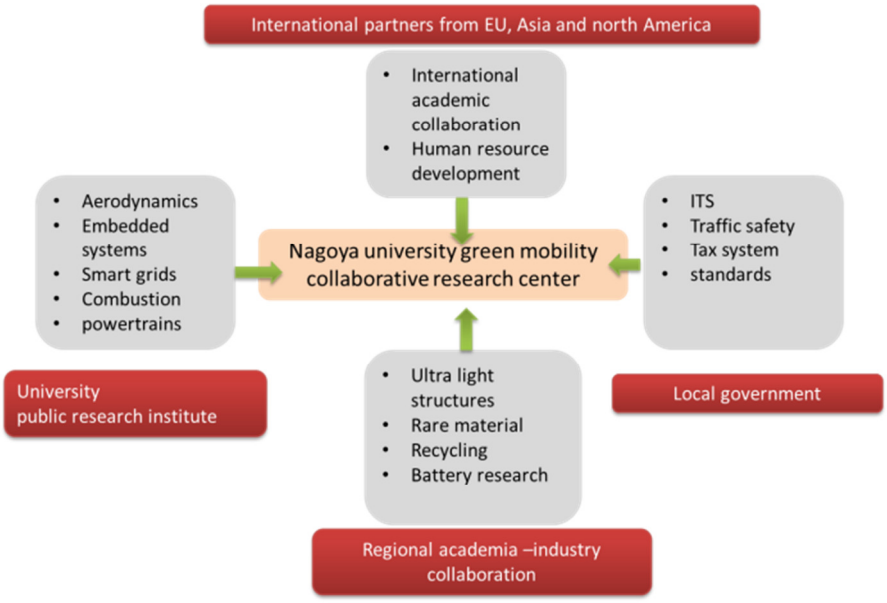

Figure 17: Green mobility collaborative research structure

Some of the highlighted projects are:
Materials group:

- High performance battery material
- Development of lightweight materials
- Development of Nano structured carbon reinforced thermoplastic
- Rare material recovery
- Material recycling

Systems group

- Driver behaviour signal processing
- Cloud computing
- Sustainable growth of cities

4.3.3. Technology competence & economic ability of the cluster

The cluster had good research infrastructure both at academia and industry level. Since this cluster contributes to 10% of Japan's GDP, it has good support to research in developing new vehicles with new technology. E.g. i-MiEV is the example of electric vehicle developed form Mitsubishi Motors from their development centre in Nagoya region. KAITEKI is an electric-assist tricycle made of products mainly created by Mitsubishi Chemical Corporation, Ltd such as carbon fibre reinforced plastic, light emitting diode, carbon-ceramic composite materials, polycarbonate resin material. The battery can be recharged via solar panels which built in an energy storage station box.

Figure 18: i MiEV from Mitsubishi Motors *Figure 19: KAITEKI : electric tricycle*

The cluster has shown a proactive trend in the area of alternate fuels especially in the area of hybrids and plug in hybrids. Automotive players in the area are actively involved in the development of new energy vehicles.

4.3.4. Cluster organization management – technological focus and organizational capability

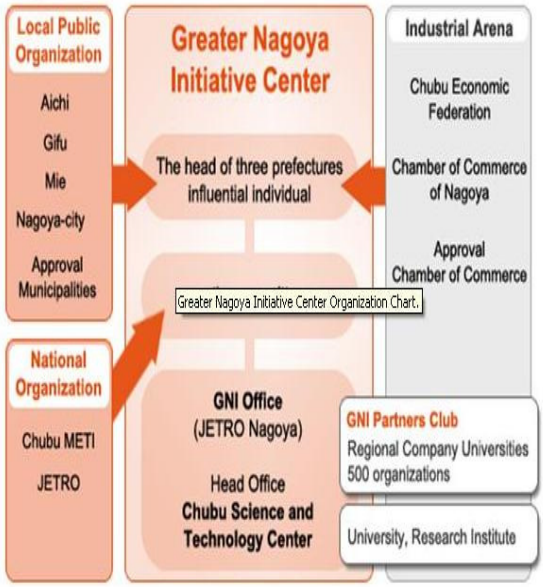

Figure 20: Overview of Greater Nagoya Initiative Centre[53]

4.3.5. Summary Nagoya

Nagoya is the largest city in the Chūbu region of Japan and also one of Japan's major ports. The Nagoya area accounts for approximately 2, 4% of the global GDP and about 10% of gross regional product in Japan which gives a certain economical ability for the region.

The Greater Nagoya region has good research infrastructure both at academia and industry level. Since this cluster contributes to 10% of Japan's GDP, it has good support to research in developing new vehicles with new technology. Toyota, Mitsubishi and DENSO for example are strong automotive players active in the region. The big global companies provide strong in-house research facilities and dominate the research and innovation agenda in the region for good and bad. Cross cultural interaction and more of triple helix structures could possibly bring more flexibility into the system.

[53] Source: http://greaternagoya.org

Research focus on material, manufacturing, environment can help for future development. There are 22 universities in the area. Nagoya University and Nagoya Institute of Technology has major contribution to science and technology development.

The cluster has shown a proactive trend in the area of alternate fuels especially in the area of hybrids and plug in hybrids. Automotive players in the area are actively involved in the development of new energy vehicles.

5. INDIA

5.1. GENERAL INTRODUCTION

This chapter provides an overview of India in order to give a sense of the history, economy, cluster policies and automotive history. A more detailed description will be presented in the benchmark of the two regions chosen in the SAGE project; The Western cluster with Mumbai and Pune regions as well as the Southern Cluster with Bangalore and Chennai regions.

India at a glance:

Population: 1,2 billion (67% live in urban areas)

Median Age: 26,5 years

Area: 3 287 263 km²

GDP: $ 4.515 trillion (2011) 1 trillion Yan

Key industrial technologies: Textiles, chemicals, food processing, steel, transportation equipment, cement, mining, petroleum, machinery, software, pharmaceuticals.

5.1.1. History

India is located in the northern hemisphere, in the south-east Asia. As the 7th largest country in the world, India stands apart from the rest of Asia, marked off as it is by mountains and the sea, which give the country a distinct geographical entity. Bounded by the Great Himalayas in the north, it stretches southwards and at the Tropic of Cancer, tapers off into the Indian Ocean between the Bay of Bengal on the east and the Arabian Sea on the west.

India is one of the oldest civilizations in the world with a kaleidoscopic variety and rich cultural heritage. It has achieved all-round socio-economic progress during the last 64 years of its independence. India has become self-sufficient in agricultural production and is now one of the top industrialized countries in the world and one of the few nations to have gone into outer space to conquer nature for the benefit of the people.

India's history and culture is dynamic, spanning back to the beginning of human civilization. Right from Indus valley civilization in ancient times to modern freedom fight and 64 years of independence India has been changing continuously. It is the blend of various cultures, religions and various languages. Constitution of India has recognized 22 different languages that are prevalent in the country, out of which, Hindi is the official language and is spoken in most of the urban cities of India.

5.1.2. Economy

The Indian economy is the fourth largest economy of the world on the basis of Purchasing Power Parity (PPP). It is one of the most attractive destinations for business and investment opportunities due to huge manpower base, diversified natural resources and strong macro-economic fundamentals. Also, the process of economic reforms initiated since 1991 has been

providing an investor-friendly environment through a liberalized policy framework spanning the whole economy. The Indian economy is estimated to grow by 6.9 per cent in 2011-12. It has grown at the rate of 8.4 per cent in each of the two preceding years. As a developing nation India places a large emphasis on higher education. It has a large number of Colleges and Universities along with a host of other specialized Institutions, Training centres and other colleges which offer a wide variety of courses to choose from. Admissions to these may be entrance based or according to your performance in the previous exam, subject to rules followed by different institutions.

5.1.3. Cluster policy

There is an awareness of the importance of cooperation and to organize research and innovation in efficient ways. Large investments are made to set up cluster facilities and the government act to create a supportive policy environment. During the liberalization process, the state government provided a favourable investment climate and supporting infrastructure, which attracted higher investment and industries.

5.1.4. Automotive sector

Today India is one of the world's largest manufacturers of tractors and two wheelers. The country is the fifth largest manufacturer of commercial vehicles and the sixth largest passenger car manufacturer in the world. The automotive industry in India is on the fast track, and provides direct and indirect employment to over 13.1 million people. Especially after the liberalization policy started in 1991, most global automotive manufacturers entered India and established local manufacturing bases through joint ventures with local partners. Foreign manufacturers and local players formed multiple clusters attracting component suppliers all over India, where they could obtain better infrastructure facilities and strong support from local governments.

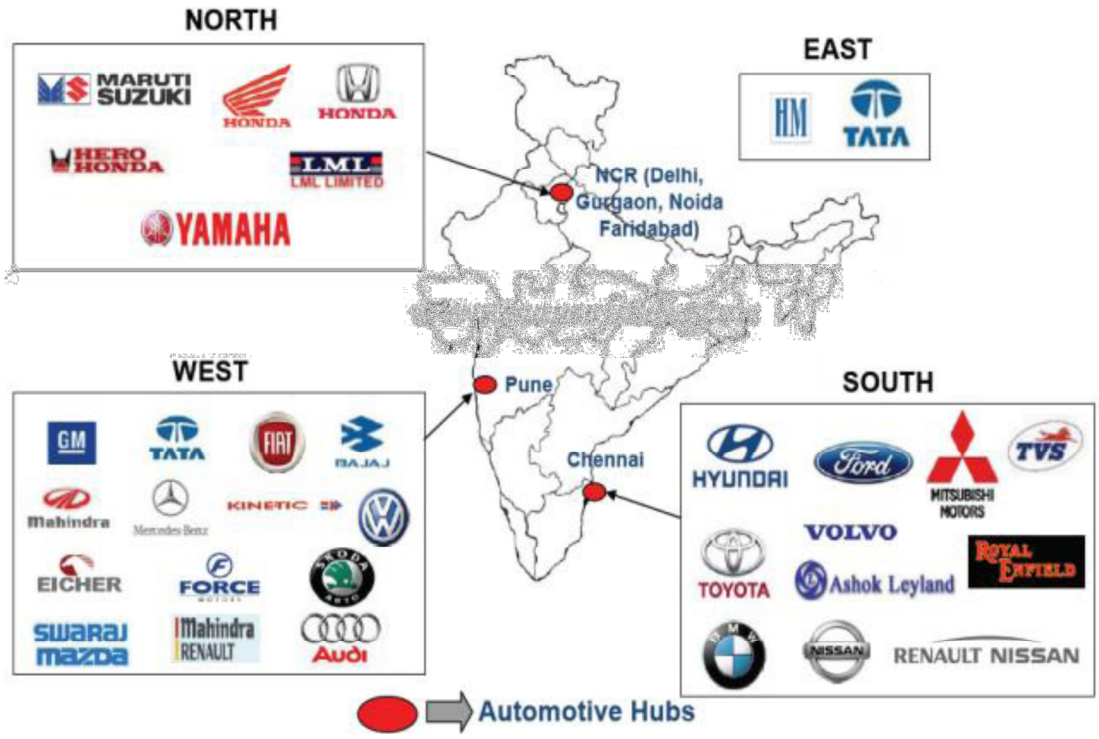

Figure 21: Overview automotive regions in India (Frost & Sullivan 2009[54])

The 2006-2016 Automobile Mission Plan set out the goal to establish India as the destination of choice in the world for design and manufacture of automobiles and auto components. The Plan target is to reach output levels of USD 145 billion, which would account for more than 10% of the national GDP and provide additional employment to 25 million people by 2016. Tata Motors Limited is India's largest automobile company. The company is the world's fourth largest truck manufacturer, and the world's second largest bus manufacturer. Tata Motors has also emerged as an international automobile company, through subsidiaries and associate companies operated in the UK, South Korea, Thailand and Spain. Among them, Jaguar and Land Rover, two iconic British brands, were acquired in 2008. Besides local OEMs like TATA Motors Ltd, Mahindra Groups, Ashok Leyland Ltd and Bajaj Auto Ltd, there are many Joint Ventures with foreign OEMs, like BMW India pvt Ltd, Volvo India pvt ltd, Ford India pvt Ltd, Hyundai motor India, etc.

5.1.5. National research bodies

Tata Institute of Fundamental Research (TIFR)[55]

The Tata Institute of Fundamental Research is a National Centre of the Government of India, under the umbrella of the Department of Atomic Energy, as well as a deemed University awarding degrees for master's and doctoral programs. At TIFR, basic research in physics, chemistry, biology, mathematics, computer science and science education is carried out. The

[54] Source: http://www.frost.com/prod/servlet/frost-home.pag
[55] Source: http://www.tifr.res.in/index.php/en/

main campus is located in Mumbai, with additional campuses in Pune, Bangalore and Hyderabad.

- School of Mathematics: Notable contributions from TIFR mathematicians include Raghavan Narasimhan's proof of the imbedding of open Riemann surfaces in C^3, C. S. Seshadri's work on projective modules over polynomial rings and M. S. Narasimhan's results in the theory of pseudo differential operators.
- School of Natural Sciences: TIFR is involved in building India's first gravity wave detector. The High Energy Physics Department, TIFR has been involved in major accelerator projects like the Tevatron, LEP and the LHC. TIFR also runs the Pelletron particle accelerator facility. School of technology & Computer Science: he school is responsible for building India's first digital computers, the TIFRAC, CDC-3600 and CYBER. Departement of Biological Studies.

The Bhabha Atomic Research Centre (BARC)[56]

It is India's premier nuclear research facility based in Mumbai. BARC is a multi-disciplinary research centre, covering the entire spectrum of nuclear science, engineering and related areas.

- BARC's core mandate is of nuclear energy, primarily for power generation. It manages all facets of nuclear power generation, from theoretical design of reactors, computerized modeling and simulation, risk analysis, development and testing of new reactor fuel materials, etc. It also conducts research in spent fuel processing, and safe disposal of nuclear waste. Its other research focus areas are applications for isotopes in industries, medicine, agriculture, etc.
- The BARC operates CIRUS (Canada India Research Utility Services), a 40 MW nuclear research reactor at their facility in Trombay.
- The BARC also conducts research in biotechnology at the Gamma Gardens, and has developed numerous disease resistant and high-yielding crop varieties, particularly groundnuts.
- It also conducts research in Liquid Metal Magnetohydrodynamics for power generation.

Automotive Research Association of India (ARAI)[57]

ARAI was founded in 1986 and have offices in Pune, Chennai, Korea & China.
Do projects for:

- Auto Industry: (biggest focus because revenue earner, 60%) Engine family up gradation for TREM III, Bus Component evaluation, Multi axis simulation of HCV, ECU Dev. for OBD
- Govt.: Nano Particle emission, Ambient Air quality, Road Profile, Biodiesel, Anthropometry data, Dual Fuel Engine, Materials Data Bank, ISS (integration of safety related ECUs)
- In-house R&D: HCNG Engine, HCCI engine, 2W Fuel Injection ECU Collaborations with Indian Universities to provide Masters Courses.

[56] Source: http://www.barc.ernet.in/about/index.html
[57] Source: https://www.araiindia.com/

- Formulation of Policies and standards (helps the government in doing so)
- R&D Services:
    - Automotive Electronics (in-vehicle n/w & comm.)
    - NVH Refinement of Vehicles and Subsystems & CAE Engine
    - Vehicle Dynamics, Structures and Material.
    - Hybrid Vehicles, ITS, EV etc. – imp for national consideration.
    - Western Cluster, Chennai Cluster, Ahmadabad, Delhi – SME imp clusters in India.
    - Service Portfolio
    - Consulting, Design & Development
    - Testing & Validation
    - Governing Committee of Auto cluster, technical consultants to them.

Auto Cluster:

The Auto cluster was established under the Industrial Infrastructure Up gradation Scheme (IIUS) of the Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India. It has the following main facilities:

- Design Centre: Support Research & Development activity for design validation by software. Also to support Re-engineering for speedy development of prototypes.
- Tool Room : To meet the tooling requirement of small and medium scale industries by extending support for manufacturing complicated / accurate large dies / molds, tooling, inspection rigs.
- Rapid Prototyping Centre: To support in prototype production (styling models, patterns, functional parts including assembly of parts).
- Rubber Polymer Lab: To develop & validate rubber/polymer products and to make necessary prototypes.
- Environment Test Chambers: To testing & validation of automotive plastic rubber, electronic component.
- Business Development Centre: To conduct exhibitions and trainings.

Advanced Research Centre for Powder Metallurgy and New Materials (ARCI)[58]

The International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) is an autonomous R&D Centre of Government of India's Department of Science and Technology (DST) located in Hyderabad. ARCI has been setup with a mission to develop unique, novel and techno-commercially viable technologies in the area of advanced materials and subsequently transfer them to Indian industries.
Under ACRI the centre for fuel technology, Chennai is doing research for development of various fuels cells and hydrogen generation and its commercialization.

Central Electrochemical Research Institute, Tamilnadu[59] is independent body under department of science and technology which is doing research in advanced batteries and fuel cell.

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[58] Source: http://www.arci.res.in/
[59] Source: http://www.cecri.res.in/

5.2. WESTERN CLUSTER MUMBAI/PUNE REGION

The following description of the regional research and innovation eco system within green and safe is provided by a local contact in India, familiar with the region.

5.2.1. Background information on the region

Maharashtra is the second most populous state and third largest state by area in India. Maharashtra is the richest state in India, contributing 15% of the country's industrial output and 13.3% of its GDP (2006–2007 figures). Mumbai, the capital city of the state, is India's largest city and the financial capital of the nation. Nagpur is the second capital of the state. Marathi is the official language.

Transport infrastructure

Power:
Maharashtra ranks first nationwide in coal-based thermal electricity as well as nuclear electricity generation with national market shares of over 13% and 17% respectively.

Roads:
Maharashtra has the largest road network in India at 267,452 kilometres. 17 National Highways connect Maharashtra to six neighbouring states. The length of National Highways in Maharashtra is 3688 kilometres. Maharashtra has a large state highway network. 97.5 per cent of the villages in the state were connected by all-weather roads as of March 2010. The Yeshwantrao Chavan Mumbai-Pune Expressway, the first access controlled toll road project in India was made fully operational in April 2002.

Western cluster at a glance:

Population: 110 million (Maharashtra)

Area: 308,000 Km^2 (Maharashtra)

GRDP: Maharashtra $179.82 billion, 15% of country GDP (2006-2007)

Key industrial technologies: Textile, sugar industry, pharmaceuticals, petrochemicals, electronics, automobiles, food processing and plastics are some examples of major industries in the area.

The Maharashtra State Road Transport Corporation (MSRTC) has been providing passenger road transport service in the public sector since 1948, linking most of the towns and villages in and around the state with a large network of operation. These buses, popularly called ST (State Transport), are the preferred mode of transport for much of the populace. In addition to the government run buses, privately run luxury buses also ply between major towns. Other modes of public transport, such as a seven-seater tempo have gained popularity in semi-urban areas.

Railways:
The state is well-connected to other parts of the country with a railway network spanning 5,983 km between four Railways. The Central Railway and the Western Railway zones of the Indian Railways are headquartered in Mumbai, at Chhatrapati Shivaji Terminus and Churchgate respectively.

The Nanded division of the South Central Railway caters to the Marathwada region of Maharashtra. The Konkan Railway, a subsidiary of the Indian Railways based in CBD Belapur, Navi Mumbai that serves the Konkan coastal region south of Mumbai and continues down the west coast of India. Maharashtra also has suburban railway networks that carry around 6.4 million passengers every day.

Ports:
The coast of Maharashtra has been a shipbuilding centre for many centuries. Companies operating shipyards in the state include Bharati Shipyard at Ratnagiri and the Rajapur Shipyards at Rajapur, apart from the state owned Mazagon Dock Limited at Mumbai.
An international cargo hub (Multi-modal International Cargo Hub and Airport at Nagpur, MIHAN) is being developed at Nagpur. MIHAN will be used for handling heavy cargo coming from South-East Asia and Middle-East Asia. Project will also include 10,000 crore (US$2 billion) Special Economic Zone (SEZ) for Information Technology (IT) companies. This will be the biggest development project in India so far.

Civil Aviation:
Most of the State's airfields are operated by the Airports Authority of India (AAI) while Reliance Airport Developers (RADPL), currently operate five non - metro airports at Latur, Nanded, Baramati, Osmanabad and Yavatmal on a 95 year lease. The Maharashtra Airport Development Company Limited (MADC) that was set up by the Government in 2002 will take up development of Airports in the state that are not under the AAI or the Maharashtra Industrial Development Corporation (MIDC). MADC is playing the lead role in the planning and implementation of the Multi-modal International Cargo Hub and Airport at Nagpur (MIHAN) project.

Maharashtra has three international airports:

- Mumbai's Chhatrapati Shivaji International Airport (among the busiest airports in India)
- Pune's civil enclave international airport with flights to Dubai and Frankfurt.
- Nagpur's Dr. Babasaheb Ambedkar International Airport.

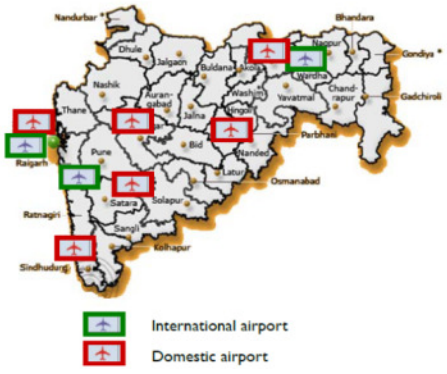

Figure 22 Airports in Maharashtra

Competitiveness and economy:

Maharashtra has made great studies in the industrial sphere with Bombay city as the centre. Maharashtra's gross state domestic product for 2011 is estimated at 901,330 crore[60] (US$179.82 billion). Maharashtra's GDP Per Capita crossed the US$ 2,000 threshold for the first time in 2011 making it one of the richest states in India. The state is ranked as the third-most urbanized state with urban population of 45% of whole population. A little bit more than 64% of the people of Maharashtra are employed in agriculture and allied activities, which makes agriculture the mainstay industry of the state.

Almost 46% of the GSDP is contributed by industry. Both food crops and cash crops are grown in the state. The total irrigated area which has been used for crop cultivation is 33, 500 square kilometres. The agricultural growth rate has increased to 1.97%. To make things more accessible for the farmers the interest rate for the loans has been decreased to 6%. A very important problem is the dependence on rainfall. To lessen the dependence irrigation facilities have been extended to an additional area of 1.4 lakh hectares. To provide relief to stressed farmers who have been affected by the drought conditions, Rs.5200 crore has been sanctioned by the central government. This has been done to six districts of the Vidharba region. To compensate the crop losses Rs367 crore has been granted to the poor farmers.

Maharashtra has had an immense history in textiles and Mumbai city was the original home of India's textile mills. Today some of the city's known for textile industry Ichalkaranji, Malegaon and Bhiwandi. Sugar industry has made considerable progress especially in the co-operative sector. Maharashtra is well known for the development of sugar industry on co-operative lines in which the farmers acquire a share in the sugar mills. Pharmaceuticals, petrochemicals, heavy chemicals, electronics, automobiles, engineering, food processing, and plastics are some of the major industries of the state.

Maharashtra is renowned for the production of three-wheelers, jeeps, commercial vehicles and cars, synthetic fibres, cold rolled products and industrial alcohol. Small scale industries have also come up in a big way in the state. Maharashtra has set up software parks in Pune, Mumbai, Navi Mumbai, Nagpur and Nasik, Aurangabad. Now Maharashtra is the second largest exporter of software with annual exports of 18 000 crore and accounts for more than 30 per cent of the country's software exports, with over 1,200 software units based in the state.
Within Mumbai is located Bollywood, the centre of India's Hindi film and television industry and India's largest stock exchange Bombay Stock Exchange, oldest in Asia. Mumbai is called as an industrial city and has been given the name of the financial capital of India. Mumbai has a concentration of industries like the chemical industry, the cotton industry, manufacturing, electricity, electrical machinery, transport equipment. Most importantly the important financial centres like the National Stock Exchange, Mumbai Stock Exchange, and Reserve

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[60] Crore (cr) = 10,000,000.

S&P CNX 500 = The S&P CNX 500 is India’s first broad-based stock market index of the Indian stock market. The S&P CNX 500 represents about 96% of total market capitalization and about 93% of the total turnover on the National Stock Exchange of India.

bank of India are located in the state. Over 41% of the S&P CNX 500** conglomerates have corporate offices in Maharashtra.

		2008-09		2009-10		2010-11	
	Unit	Mumbai	Jawaharlal Nehru	Mumbai	Jawaharlal Nehru	Mumbai	Jawaharlal Nehru
Operating income	Rs.million	870,910	965,060	959,550	1,042,060	1,028,050	1,104,600
Operating expenditure	Rs.million	748,100	375,370	870,450	393,700	937,820	430,010
Expenditure on dredging	Rs.million	51,300	22,120	25,640	24,140	22,000	18,520
Operating surplus	Rs.million	122,810	589,690	89,100	648,360	90,230	674,590
Operating ratio	%	86.00	39.00	91.00	38.00	91.00	39.00
Financial and misc. income	Rs.million	490,500	197,380	423,340	176,930	408,810	149,830
Financial and misc. expenditure	Rs.million	613,220	75,280	655,370	41,920	542,000	57,350
Total income	Rs.million	1,361,410	1,162,440	1,382,890	1,218,990	1,436,860	1,254,430

Figure 23: Financial Performance, million Rupees

Mumbai:
The city's economy got a major boost during the American Civil War, (1861-1865) with the city becoming the world's chief cotton market. In 1869, the opening up of the Suez Canal, shortened the time between the city and Europe and developed into a major port.

Up to the end of the Second World War, Bombay covered only about 67 km² of land from Colaba in the south to Mahim and Sion in the north. The city witnessed large scale Hindu-Muslim riots just before India's independence in 1947.

In 1950, the city expanded northward with the inclusion of portions of Salsette Island, and by 1957 a number of suburban towns - including Bandra, Andheri, Malad & Borivali - and some villages of Thane were incorporated into Greater Bombay, with an area of 169 square miles (434 km²).

In 1960, the city became the capital of the new state of Maharashtra. A series of land reclamations from the sea in the 1970s and the mushrooming of sky-scrapers reinforced the city's status as the premier city of the country. In 1992 large scale Hindu-Muslim riots affected the entire city. In March 1993 simultaneous bombings of the city's institutions killed 300. Since the early 2000s the city's primus status has been challenged by New Delhi, Bangalore and Hyderabad.

Pune:
Pune, when translated means "City of Virtue". The term Pune has its origin from the Hindu word of Punya - a holy place. In Hindu tradition, a confluence of two rivers is sacred, which is true for the city of Pune (Pune is located at the confluence of the Mula and Mutha rivers).

The origin of various movements - social, religious, educational, political, economic and literary- can be traced to the city of Pune.

At the turn of the century, the Deccan Gymkhana Club was set up in 1906. Electricity first came into the city in 1910 which then lead to the establishment of Napier Cinema, Pune first Cinema Hall. It ran silent movies till 1931, when it became 'talkies'. This Cinema hall still stands in Pune as Westend Talkies. In 1933, Prabhat Studio was moved to Pune. It was the most sophisticated studio in Asia at the time. Today it stands as the Film and Television Institute of India.

Pune is the 7th ranking industrial metro of India at present. Infact Kothrud has achieved a place in the Guinness book of world records for having the fastest urban growth rate.

5.2.2. Regional innovation system

This chapter describes the various players of the cluster and regional systems to support innovation.

Industry

Mumbai is India's largest city (by population) and is the financial and commercial capital of the country as it generates 6.16% of the total GDP. It serves as an economic hub of India, contributing 10% of factory employment, 25% of industrial output, 33% of income tax collections, 60% of customs duty collections, 20% of central excise tax collections, 40% of India's foreign trade and 4,000 crore (US$798 million) in corporate taxes.

Pune is the largest hub in India for German companies. According to the Indo-German Chamber of Commerce, Pune is the single largest hub for German companies from the last 60 years. Over 225 German companies have set up their businesses in Pune.

Automotive Industry:
The western hub is 33% of the automotive market. It is possible to distinguish three clusters in the area. The Chakan corridor near Pune is the western cluster with companies like General Motors, Volkswagen, Skoda, Mahindra and Mahindra, Tata Motors, Mercedes Benz, Land Rover, Fiat and Force Motors having assembly plants in the area. Another part of the western cluster is Aurangabad with Audi, Skoda and Volkswagen. An emerging cluster is in the state of Gujarat with manufacturing facility of General Motors in Halol and further planned for Tata Nano at Sanand. Ford, Maruti Suzuki and Peugeot-Citroen plants are also set to come up in Gujarat.

Main players in the region are:

- *Tata Motors:* Products include passenger cars, trucks, vans, coaches and military vehicles. Full Corporate footprint in Western Hub including most manufacturing plants
- *Jaguar & Landrover:* Assembly plant in Pune.
- *Mahindra & Mahindra*: Products include passenger cars, SUVs, MUVs, tractors, LCVs, 2-Wheelers, and military vehicles. Most of the corporate footprint in Western Hub is including manufacturing plants.
- *Fiat India Automobiles Private Limited* is a joint venture between Fiat and Tata, situated in Ranjangaon near Pune.
- *VW Group:* Full corporate footprint in Western Hub including multiple manufacturing locations.
- *Bajaj Auto:* Maker of motorcycles, scooters and cars with full Corporate footprint in Western Hub.
- *Mercedes:* Assembly plant for heavy commercial vehicles and some passenger cars in Pune. Mercedes-Benz Research and Development India is primarily in Bangalore with some presence in Pune.
- *Force Motors:* Manufacturer of three-wheelers, multi-utility and cross country vehicles, light commercial vehicles, tractors, buses and heavy commercial vehicles. JV with MAN for heavy commercial vehicles.

- *Kirloskar Oil Engines:* Major Hub for development and manufacturing.
- *Cummins India:* Manufacturer of engines. Full Corporate footprint in Western Hub.
- *General Motors:* Assembly plant and some development for passenger cars.
- *Auto Cluster R&D Inst. Ltd.*
- *Automotive Research Institute of India*
- *Continental Automotive Components* (India) Pvt Ltd
- *Premier Ltd.*
- *Tata Johnsons Control*
- *Tata Automotive Components (TACO Group)*
- *Behr India*
- *Minda*
- *Mahindra Composites Ltd.*
- *Lear Corporation*

IT & Electronics:
Maharashtra accounts for more than 30% of country's software exports with more than 1200 software units based in the state. The Government of Maharashtra is focusing on providing IT-related infrastructure, fiscal incentives to IT units and an institutional framework for the IT sector. The state has set up several state-of-the-arts IT parks to provide impetus to the IT industry.

Some of the main players in the region are e.g. Accenture, IBM, Cap Gemini, Symantec, Amdocs, Nvidia, Infosys, TCS, Wipro, Cognizant, Tech Mahindra, Persistent, Syntel, Geometric Global, KPIT Cummins, WNS, Huchisson and Willis Trinity.

Engineering:
The engineering industry in the state is highly diversified and produces a large range of machine-parts, from industrial machinery to industrial castings and forgings. The industry, which was initially concentrated in the Mumbai-Pune belt, has spread all over the state with the major production centres in Nagpur, Aurangabad, Nashikand and Kolhapur.

The major engineering items of production and export in Maharashtra are textile mill machinery, machinery for sugar, cement and chemical plants, food processing machinery, construction machinery, tractors, electric power machinery, transmission line towers, automobiles and ship building.

Some of the main players in the region are e.g. L&T, Bharat Forges, Bharat Gears, Greaves cotton, Crompton and Greaves, Siemens, ABB, Schneider Electric,Robert Bosch Group, Cummins India, Wartsila, Uhde, Behr India, Technimont India, Hindustan Dorr Olivier, Atlas Copco, Voltas and Honeywell India.

Pharmaceuticals, Oil & Gas and Energy:
The petrochemical industry has had significant growth in the state after the installation of India's offshore oil wells near Mumbai, in 1976. The state contributes 27.4 per cent to the country's chemicals, petrochemicals, oil and gas output. It also accounts for 18.2 per cent of the country's employment in the sector.

Some of the main players in the region are e.g. ONGC, HPCL, BPCL, RIL, Tata Power, Reliance Energy, Suzlon, Essar and NPCIL.

Universities and research institutes:

Maharashtra has good human resource development infrastructure in terms of educational institutions—301 engineering/diploma colleges, 616 industrial training institutes and more than 24 universities with a turnout of 160,000 technocrats every year. It is home to some of the country's best institutions.

Engineering & Sciences: Indian Institute of Technology (IIT-B), Mumbai, Visvesvaraya National Institute of Technology (VNIT), Veermata Jijabai Technological Institute (VJTI), Sardar Patel College of Engineering, University Department of Chemical Technology, College of Engineering Pune (COEP), Fergusson College, Pune, Government College of Engineering Aurangabad, Government College of Engineering Amravati, Government College of Engineering Karad, Walchand College of Engineering, Sangli (WCES), Shri Guru Gobind Singhji Institute of Engineering and Technology Nanded (SGGSIE&T).

Management: Narsee Monjee Institute of Management Studies (NMIMS), National Institute of Industrial Engineering (NITIE), Jamnalal Bajaj Institute of Management Studies (JBIMS), S P Jain Institute of Management and Research, K J Somaiya Institute of Management Studies and Research.

Arts & Law: Government Law College and Sydenham College, the oldest law and commerce colleges in India, are based in Mumbai. The Sir J. J. School of Art is Mumbai's oldest art institution. Film and Television Institute of India, National Film Archives, ILS Law College.

Medical: Armed Forces Medical College, Byramjee Jeejeebhoy Medical College, Military Nursing College.

Research & Development: With the Tata Institute of Fundamental Research (TIFR) and Indian Institute of Technology – Mumbai (IIT-B) the Western Cluster region has 2 strong organizations within the area of academia and institutes. The details of these 2 organizations are already shown in chapter 5.1.5

Other important research centres and universities are; The Bhabha Atomic Research Centre (BARC), Automotive Research Association of India (ARAI), Auto Cluster Development &Research Institute Ltd., National Chemical Laboratory (NCL: One of the leading chemical research establishments in India), Indian Institute of Science Education and Research, Pune (IISER, Pune), Inter-university Centre for Astronomy & Astrophysics (IUCCA), National Centre for Radio Astrophysics (NCRA), Centre for Development of Advanced Computing (C-DAC), Electronics Test and Development Centre (ETDC : Under the STQC directorate, it is a leading testing and certification centre) , National Institute of Virology (NIV), Indian Institute of Tropical Meteorology (IITM): Scientists at IITM has several significant achievements in tropical weather, National Informatics Centre (NIC), Armament Research Development Establishment (ARDE), High Energy Materials Research Laboratory (HEMRL), Bhandarkar Oriental Research Institute (BORI), Agharkar Research Institute (ARI), National Environmental Engineering Research Institute (NEERI)

Governmental and other public organizations

The main governmental organizations in the western cluster region are Bhabha Atomic Research Centre (BARC), Automotive Research Association of India (ARAI) and Auto Cluster. The details of these 3 organizations are already shown in chapter 5.1.5.

Innovation platform

Further Innovation platforms, which are additional to the explained organizations Tata Institute of Fundamental Research (TIFR), Automotive Research Association of India (ARAI), Bhabha Atomic Research Centre (BARC) and Auto Cluster, are currently not available.

5.2.3. Technology competence & economic ability of the cluster

The Western Cluster is comparatively new for Automotive as compared to the Eastern Cluster (Bangalore – Chennai Region). As a result the working models and government organizations present in the Bangalore-Chennai region are more mature. However, the western cluster is the new and upcoming region. The boundary of this cluster is slowly expanding to also include the state of Gujarat (region of Sanand-Mehsana). It is expected that by 2015-16, nearly one of every three cars that roll out in the country could be from Gujarat. Estimates show that in the next three-five years, half the installed capacity for making cars in India will be located in the state. Many carmakers have already shifted their focus to the region e.g. Maruti Suzuki, Peugeot PSA, Ford India and Kia Motors, Tatas and General Motors,

BUILDING CAPACITY
New projects in Sanand-Mehsana belt

Company	Capacity in million	Investment Rs crore
Maruti Suzuki	2.00	18,000
Ford India	0.24	4,000
PSA Peugeot	0.40	4,000
Kia Motors	0.30	NA

Figures based on announcements.
Kia Motors is still under discussion.
(All capacity is per annum)

Existing projects

* The Tata Nano plant has a capacity of 250,000 per annum, but can go up to 500,000

* General Motors is expanding its capacity in Halol from 85,000 to 110,000 per annum

Figure 24: Building capacity of new projects in Sanand-Mehsana belt

The Key advantages of the Western Cluster (primarily the region of Maharashtra) are:
Trade & Commerce Hub of India: Mumbai in Maharashtra is known as the trade and commerce capital of India. The city is also the financial centre of the country. In recent years, Maharashtra has emerged as a key hub for IT and ITeS, electronics, and the captive business outsourcing industries.

Policy and fiscal incentives: Maharashtra offers a wide range of subsidies, fiscal and policy incentives and assistance for businesses under the "Industrial, Investment and Infrastructure Policy, 2006". The state also has sector-specific policies for IT and ITeS, biotechnology, tourism and automotive.

Abundant labour pool: Maharashtra has a literacy rate of 76.9 per cent. The state has a large base of skilled and industrial labour, making it an ideal destination for knowledge-based and manufacturing sectors.

Facilitating infrastructure: The state has a well-developed social, physical and industrial infrastructure. It has good road, rail and port and air connectivity. Apart from eight airports, the state has two major and 53 minor ports. It also has a well-developed power supply grid.

High infrastructural growth: Maharashtra has had high growth in the infrastructure sector in the last decade. Recently, there has been a considerable increase in the number of industrial clusters, and public private partnerships projects in the in the infrastructure domain.

Stable political environment: The state has a stable political environment with a single party government. The State Governments is committed towards providing conducive business climate through progressive policies and incentives.

5.2.4. Cluster organization & management - technological focus and organizational capability

Structures and processes for clusters management

The main policies of the region originate in the corporate sector. The directions of the various organizations then get mapped as the research in the various academia and R&D institutes in the region. There is very little policy making, influencing directly the automotive industry that originates directly from the state or the central government.

Activities/services for the benefit of the members

Industrial, Investment and Infrastructure Policy: The policy aims to achieve higher and sustainable economic growth with emphasis on balanced regional development and employment generation through greater private and public investment in industrial and infrastructure development.

Key initiatives:

Institutional framework for policy implementation

Identification of thrust sectors

Building up of quality infrastructure

Incentivizing investments for employment generation in districts low on human development index (HDI).

Attracting mega investments, both foreign and domestic

Commercial exploitation of local resources and local economic potential

Strengthening the small and medium enterprises (SME) sector through promotion of quality competitiveness, research and development and technology up-gradation

Nurturing industrial clusters

Prevention of industrial sickness and revival of viable sick units

Smooth exit option for industries

Streamlining procedures, debottlenecking and creation of hassle-free, industry-friendly environment

Strengthening institutional support

Key Incentives:

Industrial promotion subsidy, up to 60 per cent of the fixed capital investment, for new small, medium and large scale units and expansion units

Special incentives for units coming up in districts low on HDI: this includes up to 75 per cent reimbursement of expenditure on account of Employees State Insurance and Employee Provident Fund scheme for a period of five years.

Customised packages of incentives for mega projects. Mega projects include industrial projects with investment of more than US$ 108.7 million or generating employment for more than 1,000 persons or investment of more than US$ 54.3 million or generating employment for more than 500 persons, depending on the location of the mega project.

Interest subsidy to new eligible units in textile, hosiery, knitwear and readymade garment sectors, ofup to US$ 76,000 for a maximum period of seven years.

100per cent exemption from electricity duty for export oriented units, IT and bio-technology for a period of 15 years. This is also applicable to other eligible units, depending on their location.

Waiver of stamp duty: 50 to 100 per cent waiver of stamp duty depending on location and type of project.

Five to 50% subsidy on capital equipment, cleaner production measures and expenses incurred on quality certification and patent registration to SMEs.

IT & ITES Policy: The policy aims make Maharashtra the most favoured destination for investments in the IT and ITES industry.

Key initiatives:

Institutional framework for policy implementation

Unique information infrastructure

Developing a pool of skilled, globally employable manpower

Industry friendly and supportive environment

Fiscal incentives

Support to IT and ITeSunits by urban local bodies.

Rewarding outstanding performance of IT and ITeSunits

Key Incentives:

Exemption from stamp duty to all IT and ITeSunits in public IT parks

75 per cent exemption from stamp duty to all IT & ITeSunits in private IT parks

Exemption from stamp duty to all IT and ITeSunits in ‘C’, ‘D’, ‘D+’ and No Industry District areas as per Package Scheme of Incentives, 2001.

90 per cent exemption in stamp duty payment for mergers, de-mergers and reconstruction of IT and ITeSunits all over the state

Stamp duty exemption to non-IT entities such as leasing and financial institutions acquiring space/premises in private and public IT parks for subsequent leasing to IT and ITeSunits.

Exemption in stamp duty to assignment leases under Section 60 and leave and licences under Section 36-A of the Bombay Stamp Act, 1958.

Sales tax at minimum floor rate of 4 per cent, on all IT products and non-IT products essential for IT and ITeSunits as approved by the empowered committee

Simplification of procedure pertaining to 'F' form and 'C' form

Maharashtra Biotechnology Policy: To develop the biotechnology industry in the state and to lead the industry to a growth path so that it can become globally competitive.

Key initiatives:

Providing appropriate policy framework to smoothen setting up of units

Providing adequate infrastructure, especially in the form of biotechnology parks

Providing appropriate package of incentives

Developing a world-class higher education and research base to serve the needs of a growing biotechnology industry and for creating high-quality employment in the state

Creating supporting institutions for the biotechnology industry for the development of human resource as well as for the applications of biotechnology

Simplifying the application of labour and other laws and procedures to accelerate the development and growth of the industry

Facilitating new ventures and innovations

Key Incentives:

Industrial power tariff applicable to all biotechnology industries engaged in the production of high-end products.

Biotechnology units throughout the state will be eligible for all the benefits available to industrial units located in specified 'D' areas of the state, under the New Package Scheme of Incentives (NPSI), 2001. These include capital subsidy for small-scale biotechnology units, and refund of octroi and similar levies.

Exemption from electricity duty

Exemption from stamp duty and registration fees in specified zones, under the NPSI, 2001.

5.2.5. Summary Western cluster – Mumbai/Pune

The West Indian Hub including the Megacities Mumbai and Pune is one if the biggest clusters in India. All main competences are available in the cluster, so are many automotive OEMs and suppliers present in the area as well as a large number of universities and research institutes. Companies like General Motors, Volkswagen, Skoda, Mahindra and Mahindra, Tata Motors, Mercedes Benz, Land Rover, Fiat and Force Motors are settled in the area. The

focus is mainly on manufacturing with a low level of mechanisation and a poor infrastructure facility.

The size of the West Indian Hub is comparable to the size of clusters in European regions. However in terms of Safe and Green Road Transport it is smaller due to less Automotive R&D activities.

The cluster is mainly organized through Automotive Research Association of India (ARAI) and Auto Cluster, which gives the opportunity to collaborate with an existing Cluster Organization, includes many major stakeholders from automotive and non-automotive sectors being available, supported by a good infrastructure and education. However the absorption of innovation and change is going quite slow.

The economic development is very strong and the human resource is ample and relatively cheap. However there is a lack of skilled and trained workforce and in general the productivity is relatively low. The policy aims to achieve higher and sustainable economic growth with emphasis on balanced regional development and employment generation through greater private and public investment in industrial and infrastructure development. Due to the lack of strong Govt. Policies/Regulations and intervention of Politics, the corruption levels is high and transparency, trust and responsibility are on a lower level. Compared to other big clusters in Asia the West Indian Hub is competitive for all leading points.

5.3. SOUTHERN CLUSTER – BANGALORE/CHENNAI REGION

The following description of the regional research and innovation eco system within green and safe is provided by a local contact in Bangalore, familiar with the region.

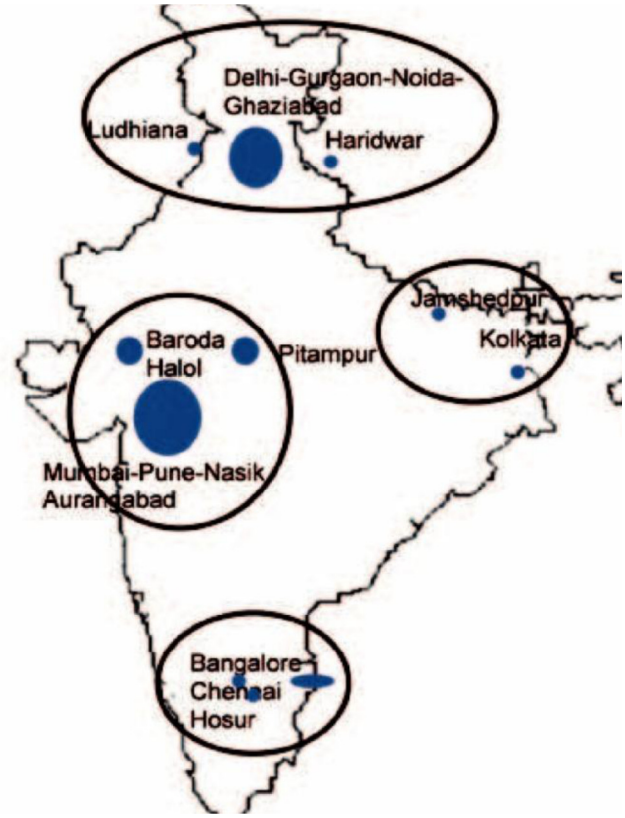

Figure 25: Overview of India

Southern cluster at a glance:

Population: 12.9 million

Area: 1930 km2

GRDP: Not available

Key industrial technologies:

Information technology

-Automotive

-Space research

-Textile

5.3.1. Background information

Chennai and Bangalore cluster are developed as one of the leading auto clusters in India. In spite of geographical proximity, Bangalore and Chennai show different types of pattern in terms of their development. Chennai and Bangalore are 300 km apart but as they are in different states of India Tamil Nadu and Karnataka respectively. The culture, language, socio-economic trends are different in these states.

Karnataka[61]

Demography

It is the government state in India located in south India. According to census 2001, the population of Karnataka is 52, 850,562 with 34% urban population. The literacy rate in

[61] Source: http://en.wikipedia.org/wiki/Karnataka; http://www.karnataka.gov.in/Pages/Default.aspx

Karnataka is 66.6%.Kannada is the official language of Karnataka and spoken as a native language by about 64.8% of the people.

Economy

Karnataka is one of the high economic growth states in India with the expected GSDP (Gross State Domestic Product) growth of 8.2% in the fiscal year 2010-2011. The GDP is expected to be $ 46 bn. It has received foreign direct investment worth $ 2 Bn in 2008-09 making it as 3rd most preferred destination in India.

Karnataka is the manufacturing hub for some of the largest public sector industries in India, including Hindustan Aeronautics Limited, National Aerospace Laboratories, Bharat Heavy Electricals Limited, Indian Telephone Industries, Bharat Earth Movers Limited and Hindustan Machine Tools, which are based in Bangalore. Many of India's premier science and technology research centres, such as Indian Space Research Organization, Central Power Research Institute, Bharat Electronics Limited and the Central Food Technological Research Institute, are also headquartered in Karnataka. Mangalore Refinery and Petrochemicals Limited is an oil refinery located in Mangalore. Volvo, TVS, ABB, Toyota, General motors, TATA motors are the major player in automotive sector.

Tamil Nadu[62]

Demography

Tamil Nadu lies in the southernmost part of the Indian Peninsula. Tamil Nadu is the seventh most populous state in India with a population of 72,138,958 (5.96% of India's population according to Census 2011. It is the seventh most densely populated state in India with a population density of 555 persons per square kilometre. Tamil Nadu has 80.3% of the literacy rate. India has a human development index calculated as 0.619, while the corresponding figure for Tamil Nadu is 0.736, placing it among the top states in the country. Tamil is language for Tamil Nadu state. Tamil is one of the oldest language in India .It also has highest level of urbanization in India with 49% people in cities.

Economy

Tamil Nadu's gross state domestic product for 2011 is estimated at US$ 97.970 Billion. It has also attracted foreign direct investment of US $ 5bn.It is also the highest industrialized state in India. Automobile, textile, heavy industries, leather are major industries in Tamil Nadu.

History of Bangalore[63]

Bangalore also called Bengaluru is the capital of the Indian state of Karnataka. Located on the Deccan Plateau in the south-eastern part of Karnataka, Bangalore is India's third most populous city and fifth-most populous urban agglomeration. Bangalore is well known as a hub for India's information technology sector. It is among the top 10 preferred entrepreneurial locations in the world.

It has a long history, right from 1537 AD during Vijaynagar Empire to state of Mysor, British and today as a modern city and capital of Karnataka.

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[62] Source: http://en.wikipedia.org/wiki/Tamil_Nadu

[63] http://en.wikipedia.org/wiki/Bangalore

Bangalore is India's second fastest growing metropolitan city. With 10.2% of growth rate it contributes to 52,346 crore. It is one of the fastest growing markets for FMCG goods. The literacy rate in Bangalore is 89%. Bangalore hosts many institutes in the area of scientific research, engineering, design, fashion and management.

History of Chennai[64]

Chennai is the capital city of the Indian state of Tamil Nadu. It is a major commercial, cultural, and educational centre in South India, while the port of Chennai is the second largest port in India. Though the city has been in the major south Indian kingdoms, the cities written history can be found in the British era. Chennai accommodates approximately 8.9 million people. The literacy rate in Chennai is 90 % which is much higher than national average.
The city is base to around 30% of India's automobile industry and 40% of its auto components industry. It is expected to grow to $100 billion economy by 2025. It has a diversified economic base anchored by the automobile, software services, hardware manufacturing, and health care and financial services industries.

5.3.2. Regional innovation system

This chapter describes the various players of the cluster and regional systems to support innovation. Bangalore and Chennai is hosting various automotive R&D centres. Many global players have started their R&D centres and manufacturing facility in Bangalore and Chennai region. It is also supported by their suppliers' base in this region.

Chennai: Ashok layland, Ford, BMW, Renault Nissan, Nissan, Mitsubishi Motors, TVS, Mahindra
Bangalore: Volvo, General motors, Mercedes Benz, Toyota, Tata Marco polo
Hyderabad: Hyundai

This region is supported by the industrial training institutes (ITI), policies from central as well as state government and industry academia collaboration.

Industry

Mahindra Reva electric vehicles[65] located in Bangalore, it is responsible for one of the largest deployed fleet of electric vehicles with 3000 vehicles sold globally. It is in construction of new plant facility with capacity of 30000 vehicles per annum.

General Motors India started its Indian journey in 1996 and offers products under the Chevrolet brand in the country**.** General Motors Technical Centre Located in Bangalore is one of the 10 design Studios, 8 R&D facilities and 12 Engineering Facilities around the word. It is actively involved in Research, Design, Analysis and Development of vehicles and Powertrains both globally and for the Indian market.

Volvo has its engineering design centre and production facility in Bangalore with trucks, buses and construction equipment and industrial engines as main products. It supports the

[64] Source: http://en.wikipedia.org/wiki/Chennai
[65] Source: http://www.petrolfreeworld.com/Reva-Home.html

product development activities for Asian as well as US and European market with its competent technical capabilities.

Bosch group many group companies around Bangalore like Bosch Ltd. Robert Bosch Engineering and Business Solutions Ltd., Bosch Automotive Electronics India Pvt Ltd... It started operations in 1953 and now had grown to 14 manufacturing facilities and 3 development centres. It has spent around 4 bn euros for research globally. It deals with various automotive solutions in the area of electronics, powertrain, controls, services, fuel systems. It is also making collaborations with local academia for research collaboration.

Delphi India: Delphi India was incorporated in April 1995 as a wholly owned subsidiary of Delphi. Located in Bangalore, Delphi India's Technical Centre India (TCI) has emerged as the largest Delphi technical centre outside of the United States. TCI complements Delphi's strong manufacturing base in India and in the rest of the Asia Pacific region. It deals with the areas of embedded systems, mechanical engineering, product engineering and design. Delphi India is also involved with bi-fuel, CNG (compressed natural gas) and gasoline engine management system activities.

Bharat Benz a 100% owned subsidiary of Daimler AG in India has built a test track in Chennai for vehicle testing in Indian conditions.

Ashok Leyland is second largest player in the Indian truck and bus market. It has research and development facility along with engine development in Chennai. They are having joint venture with Renault Nissan group and have joint venture in the area of vehicle, powertrain and technology development.

Mahindra and Mahindra is leader in Utility vehicle segment in India. It has inaugurated new facility called Mahindra research valley in Chennai. It would have development facility for future vehicles from Mahindra. 34 labs are established for research in vehicular technologies like alternate fuels, reliability, safety and polymer technology. It also planned for making electric and hybrid vehicle with fuel cell by 2015. It has established R&D centre for it.

Renault Nissan Chennai also hosts the Renault Nissan Technology and Business Centre which supports the global operations of partners in the area of advanced CAE, product development, digital vehicle development, information system development and sourcing.

Hundai has opened a global design centre in India to support the CAD, CAE and other development activities globally.

Visteon one of the largest automotive supplier in the area of Interior, climate, lighting and engine induction has many research centres in India out of which it has Technical Centre & Customer Service Centre in Chennai. It is in operation since 2006.

Valeo is one of the global suppliers in the area of comfort and driving assistance systems, powertrain system, thermal and visibility systems. It has its R&D centre in Chennai focusing core product areas.

Continental AG is leading automotive supplier. It has focused research in emerging markets with tagline of ‘affordable cars’. It has employed about 600 engineers.

Caterpillar Engineering design centre, Chennai is one of the 6 R&D sites globally. Cater pillar has is working on various new technologies to cater customer demands through

innovation. They are working on areas like: Next generation powertrains, hybrid, autonomy, alternative fuels and engine emissions and efficiency. They are working with Indian and global automotive OEMs along with their global and local suppliers making the Chennai and Bangalore area a hub.

Academia and institutes

Indian institute of sciences (IISC)[66], Bangalore

IISc has grown to become India's premier centre for research and postgraduate education in science and engineering. The evolution of the Institute over the past one hundred years has mirrored the development of science and technology in India. The Institute offers a variety of Master's degree programs in Engineering, an integrated Ph.D. program in Sciences and Ph.D. programs in a wide spectrum of disciplines in science and engineering. It has masters as well as research programs in major engineering and sciences. IISC also hosts various centres which provides interdisciplinary research like centre for infrastructure, sustainable transport and urban planning (SiSTUP), Centre for sustainable technologies, material engineering. SiSTUP has stated with seed money from government of Karnataka authorities like Bangalore Development authority (BDA), Directorate of urban land development, Bangalore Metropolitan transport corporation (BMTC). IISC has good industry collaboration network. Bosch has signed a MoU for a research centres and granted ` 150 Cr. For next 10 years. Under this program a program is starting in the field of air pollution measurement transport solution in collaboration with IBM. It also has research collaboration with universities in Europe, Asia and China. IISC has MoU signed with Chalmers University and Royal Institute of Technology for cooperation for research in Sustainability Science, Biological Sciences, Mathematical Sciences, Automotive and Vehicle Engineering, Physics.

Indian Institute of Technology, Madras, Chennai[67].

IIT Madras founded in 1959 by the support of West Germany, is one of the important school of engineering and technology in southern India. It has 360 faculties and around 6000 students for undergraduate and post graduate programs. It hosts department in the area of engineering, sciences and humanities. It has excellent collaboration with the automotive industries. It has some facilities for automotive research such as:

- Raghupati Singhania Cenrtre for Tyre and Vehicle Mechanics
- Vehicle Dynamics lab
- Caterpillar Centre of Excellence for Heavy Vehicles Engineering Modal Analysis and fatigue laboratory
- Autodesk-IITM Centre of Excellence for CAD
- IIT madras has MoU signed with ministry of urban Development, government if India and establishes centre of excellence in Urban transport system. It works on sustainable transport and intelligent transport systems. It has done some research projects in the transportation engineering with the help of other institutes like NIIT Calicut, NIIT Trichi, and Anna University.

[66] Source: http://www.iisc.ernet.in/
[67] Source: http://www.iitm.ac.in/

- IIT Madras handles collaborative project through industrial consultancy and sponsored research.

IIT Madras Research Park is an independent company promoted by IIT Madras and its alumni. The IIT Madras Research Park facilitates the promotion of research and development by the institute in partnership with industry, assisting in the growth of new ventures, and promoting economic development.
Department of engineering design deals with the interdisciplinary research in the area of biomechanics, medical devices, physiology and ergonomics.
In recent years, IITM has received many collaborations initiative from Industry. To name a few:

- Danfoss has announced the signing of a Memorandum of Understanding (MOU) with IIT Madras, India, an education institute with expertise within research in power electronics and power quality solutions. The collaboration will enhance new technologies in Climate & Energy.
- IBM announced that it has signed a research collaboration agreement with IIT Madras and IIT Kharagpur to develop systems that will help power grids become more efficient and resilient.
- IITM and Nissan have signed a MoU for collaboration till 2015. The support is for having good support for Nissan's operations in India through which some training sessions were arranged at Nissan's R&D centre in India.

International Institute of Information technology, Bangalore[68].

IIIT is a deemed university funded by government of Karnataka and IT industries. It is founded in 1999.Due to its location in Bangalore, vicinity to IT cluster like ITPL or electronic city and public private partnership model, it has collaborations with many IT companies. Some companied helped to set up a lab.

- Siemens Vision Lab
- Honeywell Automation Lab
- Intel Planet Lab
- Intel Community PC Lab
- HP IMS Lab

Anna University

Anna University is one of the premium technical universities in city of Chennai. Founded in 1978, it integrates four technical institutes in Chennai city. It has around 2000 undergraduate students and 300 master's students.
Madras Institute of Technology affiliated to Anna University has Centre of Automotive research and training (CART) established in 1997. It mainly caters to in regard to design, research, consultancy and training. The collaboration is handled by Centre for University Industry collaboration.

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[68] Source: http://www.iiitb.ac.in/

Anna University's urban energy centre is a collaborative research centre between Anna University and Ryerson University. They are expanding the research areas into renewable energy, energy storage, smart grid, electrical vehicle and infrastructure.

Vellor Institute of technology (VIT)[69]

VIT is founded in the year of 1984 as a self-financing institution. It offers 18 undergraduate and 34 post graduate programs and hosts international students. It offers research in the area of CAD/CAM, product design, biomedical, IT, nanotechnology and automotive.
Automotive research Centre (ARC) was established under the infrastructure development of science and technology (FIST) program. Alternate fuels, emission control, engine management, NVH and safety are the area of focus. It has partnership between Automotive Research Association of India, Turbo energy Ltd., CVRDE, Admednagar for consultancy projects and common programs.

Governmental and other public organizations

Ministry of Heavy industries and public enterprise

It is nationwide authority which decides the policy for infrastructure development and industry policy. Auto policy 2006-2016 is a part of the initiative. India's policy about electrical vehicles is expected to release in the month of May 2012.

National Electric Vehicle Mission Policy

Government has announced the 4B$ national electric vehicle mission policy under which India has put a target of 6 million electric vehicles till 2020.It will boost the use of electric and hybrid vehicles in India. It predominantly will have huge effect on two wheeler market. 100% growth is expected from industry partners.

Ministry of science a technology

Ministry of science and technology has several bodies which envision the growth of science and technology in India. It provides policies, collaboration and finical support to individual, industry or community through government bodied under ministry as described below.

Department of science and technology (DST)

Department of Science & Technology (DST) was established in May 1971, with the objective of promoting new areas of Science & Technology and to play the role of a nodal department for organizing, coordinating and promoting S&T activities in the country. It's main function to act as advisor to government, formulating the policies about development of science and technology. It helps for cross linking of various institutions and department having capability.

Technology Development Board (TDB)

Technology development board aims at accelerating the development and commercialization of indigenous technology or adapting imported technology to wider domestic application. The Board provides financial assistance in the form of equity soft loans or grants.

Technology Information, Forecasting and Assessment Council (TIFAC)

[69] Source: http://www.vit.ac.in/

TIFAC is an autonomous organization set up in 1988 under the Department of Science & Technology to look ahead in technologies, assess the technology trajectories, and support technology innovation by network actions in select technology areas of national importance. In 1993, TIFAC embarked upon the major task of formulating a Technology Vision for the country in various emerging technology areas.

Department of Scientific & Industrial Research (DSIR)

DSIR is enabling Indian industry to reach state-of-the-art innovation excellence and competitiveness through research & technological interventions. It offers various programs, funding opportunities to support the development in technological roadmap for India.

Ministry of urban development

The Ministry of urban development is responsible for development of urban infrastructure development and transport Indian urban areas. With rapid urbanization it has steps for transport infrastructure development through projects like Jawaharlal Nehru National Urban Renewal Mission (JN NURM). Urban transport policy, use of cleaner technology, safe transport is on priority for the ministry. Urban transport summit 2012 in New Delhi on 25th May will be crucial in this matter.

Ministry of new and renewable energy (MNRE)

MNRE has taken up the following programs on various New Technologies, as part of these programs, research, development and demonstration projects have been initiated at various research, scientific and educational institutes, universities, national laboratories, industry, etc. These projects are helping in the development of indigenous research and industrial base, expertise, trained manpower and prototypes/devices/systems in the country.

- Hydrogen Energy
- Chemical Sources of Energy (Fuel Cells)
- Alternative Fuels for Surface Transportation

State government and councils

Support the central government policies through their local policies and infrastructure. They also provide the individual state wise policies which foster research and development in the area and develop industries.

Karnataka pollution control board

The control board is the regulatory authority in Karnataka state for measurement and control of the pollution. It has taken work to measure and control the air quality in city of Bangalore.

Professional organizations e.g. Chambers of Commerce

Confederation of Indian industries (CII) works to create and sustain an environment conducive to the growth of industry in India, partnering industry and government alike through advisory and consultative processes. Founded over 117 years ago, it is India's premier business association, with a direct membership of over 7000 organizations from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 90,000 companies from around 400 national and regional sectorial associations. CII enables change by working closely with government on policy issues, enhancing efficiency, competitiveness and expanding business opportunities for industry through a range of specialized services and global linkages.

The CII Theme for 2012-13, '*Reviving Economic Growth: Reforms and Governance,'* accords top priority to restoring the growth trajectory of the nation, while building Global Competitiveness, Inclusivity and Sustainability.
CII has their regional chapter's .In Chennai, Bangalore and Hyderabad they have local branches which support the industries in these areas.

Federation of Indian chambers of comers and industry (FICII) Founded in 1927; it is non-profit, non-government organization. It acts as voice of Indian industry and plays key role in the thought process, policy change and implementation. It provides various services in the area of finance, tax, investment, world trade through various events and exhibitions.
They organize various activities related to the development of industry and new sectors. For example, 'India urban transport summit' may 2012.

Society of Indian automotive manufacturers (SIAM) is the apex Industry body representing 46 leading vehicle and vehicular engine manufacturers in India. SIAM also interacts with worldwide experts to assess the global trends and developments shaping the Automotive Industry. It has been actively pursuing issues like Frontier Technologies viz. Telematics: Promotion of Alternative Fuels including Hydrogen Energy for automotive use through cell vehicles and Harmonization of Safety and Emission Standards etc.
Automotive Component Manufacturers Association (ACMA)
The Automotive Component Manufacturers Association of India (ACMA) is the nodal agency for the Indian Auto Component Industry.
Its active involvement in trade promotion, technology up-gradation, quality enhancement and collection and dissemination of information has made it a vital catalyst for this industry's development. Its other activities include participation in international trade fairs, sending trade delegations overseas and bringing out publications on various subjects related to the automotive industry. It help to maintain the quality and promotes export .It has regional offices in auto cluster region like Chennai and Bangalore.

Development agencies, e.g. business incubators, science parks, technology transfer agencies, fundraising, Trade shows

Various bodies related to automotive domain organize various events related to clean and green technologies .SIAM, ACMA, CII, FICCI are the main organizers.

Auto expo July 2012 Chennai Auto Expo is aimed at tapping the flourishing auto market in South India and providing a cost effective platform for product display. Along with this, maximum brand exposure will be ensured by appropriate promotional campaigns and similar activities.
Automotive Testing Expo Chennai India this expo exhibits various developed technologies in safety, NVH, automotive electronics, cleaner technologies for engine. Many global players visit the event like MTS Systems, Horiba, National Instruments, Automotive Test Systems, and AVL. Next event is planned in 2014.
Automotive engineering show 2013, Chennai This platform provides OEM, tire1 and tire2 suppliers to demonstrate their capability. It offers opportunity connects to providers of systems and processes to optimize efficiency, quality and costs. It focuses on IT, manufacturing technology, robotics, automation.
ACMEE - International Machine Tools and Auto component exhibition, Chennai ACMEE is a biennial even. The first edition was held in 1994 and since then 9 editions have already been

held. The 9th edition was held in June 2010 and it was acclaimed as the greatest show on manufacturing technology in this Region
The events are organized in the main cities crucial for automotive development like New Delhi, Mumbai, Pune, Chennai, and Bangalore.

Technology transfer, industry promotion

Tamil Nadu technology development and promotion centre (TNTDPC), was conceived as a one-stop shop for Technology Development & Promotion, Technology Up gradation and Induction of New Technologies in Tamil nadu as a unique model in the country. The major task of the Centre is focused towards providing a helping hand to the Small & Medium industries and entrepreneurs in TN to reach and compete in global market place through technology innovation and meeting international standards.

Karnataka trade promotion organization (KTPO) is a joint venture between India trade promotion organization and Karnataka Industrial area development board. It is established to promote the domestic as well as international trade in the state of Karnataka.

International Technology Transfer Program (ITTP) This program is offered by department of science and technology. The objective of this program is Promoting transfer of technologies, projects and services from India with a view to enhance the reach of Indian industry beyond the national boundaries as well as promoting transfer of technologies from other countries to India with a view to enhance the technology export capability of Indian industry.

Karnataka Industrial Area Development Board (KIADB) is the state government responsible for development for development of Industrial infrastructure in the state of Karnataka. Development of SEZ, Industrial parks in the responsibility this entity.

Tamil Nadu Industrial De Tamil Nadu Industrial Development Corporation (TIDCO) Tamil Nadu Industrial Development Corporation Limited (TIDCO) was established in 1965 as a Government of Tamil Nadu Enterprise to stimulate industrial development and leverage capital investment through joint ventures. It supports large scale infrastructure projects. Some of the projects are Special economic Zone (SEZ) at Hosur. Hosur is city in State of Tamil Nadu which is very near from Bangalore.

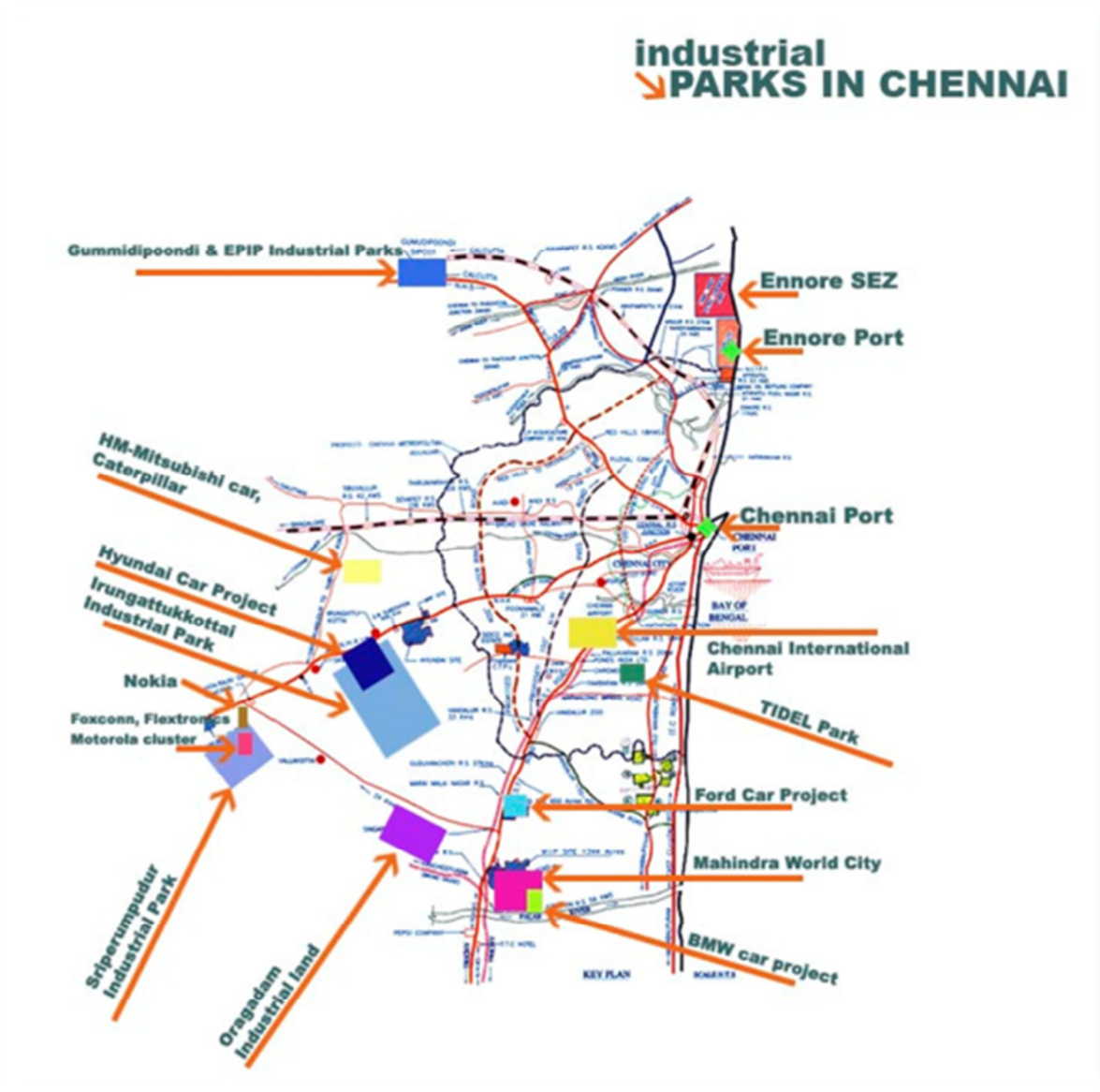


Figure 26: Industrial parks in Chennai

5.3.3. Technology Competence & Economic Ability of the cluster

Specific technology competences available in the cluster:

- Competency in Complete vehicle development
- Presence of Global supplier in vehicle technologies like powertrain technology, exhaust after treatment, automotive electronics, transport solutions which are important for development of greener technologies.
- Established player in electric vehicle (Mahindra reva)
- Presence of Research bodies in the field of new and alternate fuels like Central fuel cell research institute

Areas the cluster has been innovative within:

The cluster is now leader in new venture establishment and is working on new initiatives for implementation of safety, better infrastructure and services. This shows that clusters in other field like IT is also contributing to the development of automotive domain services and products e.g. IBM-IISC collaboration for automotive transport solutions.

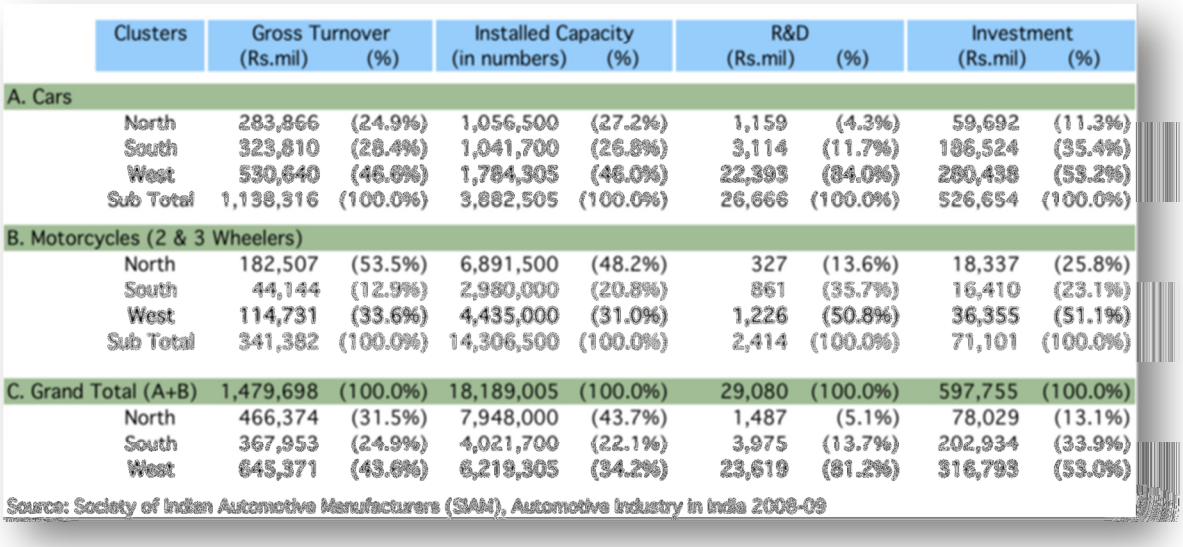
The cluster compared to other regions:

Chennai –Bangalore cluster has some different characteristics as compared to other clusters like Mumbai-Pune regions or NCR (national capital region) cluster.

Chennai-Bangalore cluster is established since 1950's. It has established supplier base. It focuses mainly on the Indian Market than exports.

It has attracted many multinational players to start venture in this region.

The Chennai- Bangalore region is more adaptable for up gradation since it has taken many initiatives for modernization of bus fleets. Bangalore municipal transport and Karnataka state road Transport Corporation has biggest fleet of VOLVO buses in country and it is widely accepted by people.



Clusters	Gross Turnover (Rs.mil)	(%)	Installed Capacity (in numbers)	(%)	R&D (Rs.mil)	(%)	Investment (Rs.mil)	(%)
A. Cars								
North	283,866	(24.9%)	1,056,500	(27.2%)	1,159	(4.3%)	59,692	(11.3%)
South	323,810	(28.4%)	1,041,700	(26.8%)	3,114	(11.7%)	186,524	(35.4%)
West	530,640	(46.6%)	1,784,305	(46.0%)	22,393	(84.0%)	280,438	(53.2%)
Sub Total	1,138,316	(100.0%)	3,882,505	(100.0%)	26,666	(100.0%)	526,654	(100.0%)
B. Motorcycles (2 & 3 Wheelers)								
North	182,507	(53.5%)	6,891,500	(48.2%)	327	(13.6%)	18,337	(25.8%)
South	44,144	(12.9%)	2,980,000	(20.8%)	861	(35.7%)	16,410	(23.1%)
West	114,731	(33.6%)	4,435,000	(31.0%)	1,226	(50.8%)	36,355	(51.1%)
Sub Total	341,382	(100.0%)	14,306,500	(100.0%)	2,414	(100.0%)	71,101	(100.0%)
C. Grand Total (A+B)	1,479,698	(100.0%)	18,189,005	(100.0%)	29,080	(100.0%)	597,755	(100.0%)
North	466,374	(31.5%)	7,948,000	(43.7%)	1,487	(5.1%)	78,029	(13.1%)
South	367,953	(24.9%)	4,021,700	(22.1%)	3,975	(13.7%)	202,934	(33.9%)
West	645,371	(43.6%)	6,219,305	(34.2%)	23,619	(81.2%)	316,793	(53.0%)

Source: Society of Indian Automotive Manufacturers (SIAM), Automotive Industry in India 2008-09

Figure 27: Automotive cluster economics 2008-2009

This cluster hosts vehicle development in all variety of sectors from car, two wheeler, commercial vehicles also defence vehicles. It is well supported by infrastructure development and government policy. The cluster has a good network of Tire I and Tire II suppliers.

It hosts Bangalore and Chennai two of the fastest developing cities in India. Both cities together are serving to over 18 million people and these figures are increasing. These city corporations are developing infrastructure for transport like 'Namma metro' .BMTC (Bangalore municipal transport corporation), Municipal transport corporation (MTC), Chennai have plans for expansion of services and have cleaner vehicles.

Chennai is a metropolitan city and Bangalore is tire I city. Introduction of new emission standard takes place in these cities so it has acceptance to greener technologies.

5.3.4. Cluster organization and management – technological focus and organizational capability

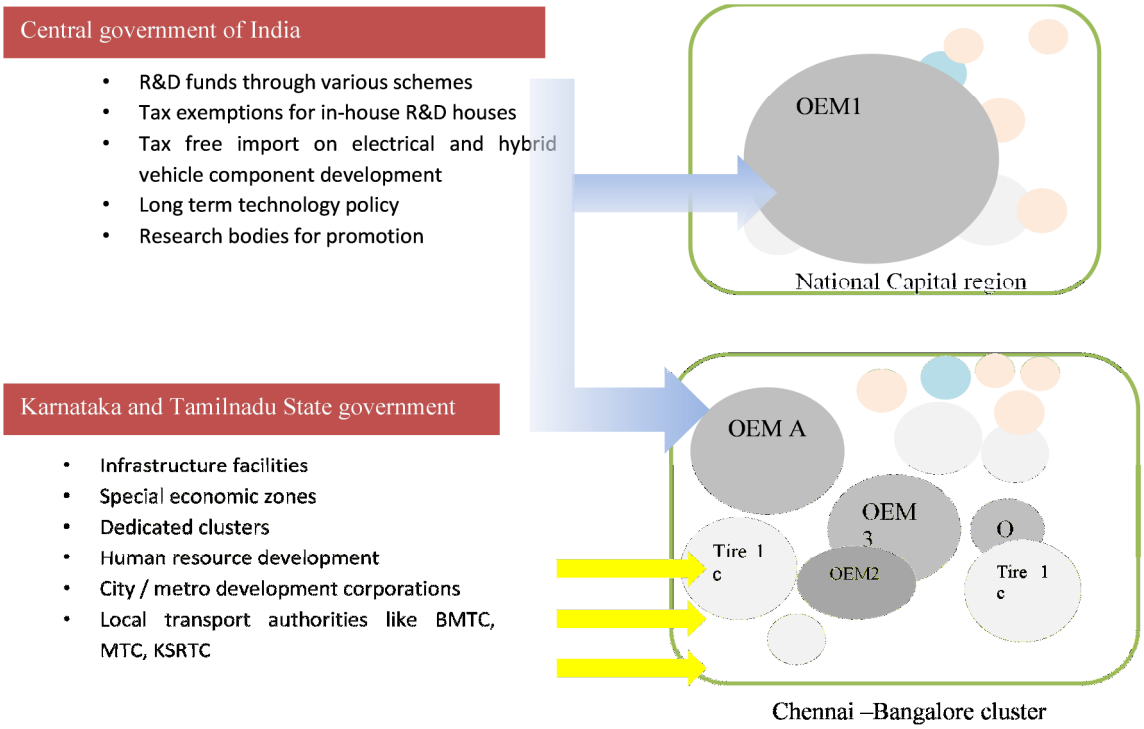


Figure 28 Structure and process in Auto cluster

5.3.5. Summary Southern cluster – Bangalore/Chennai

Bangalore/Chennai automotive cluster is one of the older clusters in India. Many Indian automotive OEM started their operations in India and they are supported by the strong tire one suppliers.
Chennai and Bangalore cities are one of the fastest growing cities in India. Local state government is supporting the growth of the industry through providing infrastructure, skilled man power development and financial support to the new initiatives. Central government provides the umbrella support though various industry specific policies like Auto policy. Recently launched for new policy electric vehicles will boost the initiative towards the electric and hybrid vehicle development. It will provide the opportunity of 4 b$ market till 2020 with 6 million vehicles predominantly 2 wheelers.

Bangalore and Chennai clusters are well supported by supply of talent pool from many engineering collages in the region with premium institutes like Indian institute of sciences, Bangalore, Indian Institute of Technology, Madras and Indian Institute of management, Bangalore. These institutes are also proactive in having industry collaboration and promoting research and entrepreneurship. Bangalore being the 'IT hub' of India has many multination companies as central location complementing the automotive industry for services and software development. It is very evident from many global companies like Bosch, Continental, Delphi, General Motors, Mercedes Benz have their development centre in this cluster,
Moving ahead with this encouraging scenario, the cluster is facing challenges like mismatch between the growth rate of city and infrastructure development, corruption. Indian market is majority driven by cost and consumer demand hence acceptance to the new energy vehicle as a business case will largely depend on the government support. There is need to strengthen the industry and academia relations with defined policies such as intellectual properties, funding.

Increased interaction between the mature clusters, academia and local industry can bring considerable awareness in the system.

6. SOUTH KOREA

6.1. GENERAL INTRODUCTION

This chapter provides an overview of South Korea in order to give a sense of the history, economy, cluster policies and automotive history. A more detailed description will be presented in the benchmark of the two regions chosen in the SAGE project the Busan/Ulsan region and the Daejeon region.

6.1.1. History

The Republic of Korea is a small country on the far eastern edge of Asia. Korea was colonized by Japan in the early 20th century and after the World War II had to endure the Korean War (1950-1953), but it has achieved amazing economic growth in a short period, dubbed "the Miracle on the Han River."

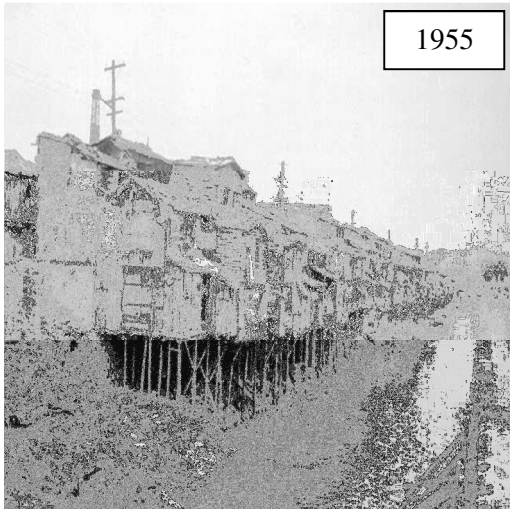


Figure 29: Illustrates the development of the city during the last 55 years.

South Korea at a glance:

Population: 49 million (85% live in urban areas)

Median Age: 38 years

Area: 99 720 km² (1/6 of France area)

GDP: US$1014 billion in 2010

Key industrial technologies: Automobile, Shipbuilding, Semiconductor, IT, Display, Machinery & Manufacturing

6.1.2. Economy

Although South Korea ranks 109th in the world in terms of land area, the country is a centre of economic activity, culture, and arts. Today, the Korean economy is the 15th largest in the world.

The impressive economic and technological progress South Korea has been demonstrating for last several decades has brought the country to the forefront of the global powerhouses. This progress is firmly rooted in the principles of the knowledge-based economy that South Korea is consistently pursuing. This exceptional economic success has been driven by a firm commitment to innovation. Among its strengths, Korea has one of the highest rates of spending on R&D in the world, much of is performed by private firms. It also has a highly educated labour force with a strong interest in science and technology. Korean RTD expenditures are above 4% of the national GDP, well above Europe and the OECD average. Korea is among the most technologically advanced and digitally connected countries in the world and a recognized market leader in electronics, mobile communication, shipbuilding and automotive with well-known multinational conglomerates (chaebols) like Samsung, LG and Hyundai.

The Korean economy, among the most open in the world, is therefore very sensitive to global changes and has been hardly impacted by the 2008-2009 crises. Taking advantage of the recovery in external demand, particularly from Asian countries including China, it has now returned to the path of sustained growth (+4%) and ambition to develop new sources of growth in the sustainable development sectors: renewable energy, electric vehicles, and public transport.

With 11% of Korean exports the European market is the second outlet after China. The EU-South Korea free trade agreement is in effect since July 2011.

6.1.3. Cluster policy

The Korean government strongly supports cluster development thanks to its agency KICOX[70] (Korea Industrial Complex Corp.).

Under the authority of the Ministry of Knowledge Economy, KICOX plays a leading role in cluster development and in enhancing corporate competitiveness. It is an industrial complex management and supervision agency which was established in 1964 after integrating five regional industrial complex management corporations. In2004 KICOX has been designated as a Cluster promotion agency and leads the e-cluster program[71]

KICOX manages the “industrial complex cluster program”. The implementation of this program was started as a part of the national balanced development policy from 2004 to

[70] Source: http://www.kicox.or.kr/home/eng/index.jsp
[71] Source: www.e-cluster.net/en

transform existing factor-driven-production-centred industrial complexes into knowledge-based clusters that can act as virtuous circles of creation and innovation.

The agency promotes a variety of projects such as the advance and restructuring of industrial complex structure, creation of customized space, improvement of the competitiveness of industrial clusters, establishment of Eco-Industrial Park, establishment & operation of industrial complex support facilities and free agency service for factory establishment.
Primary duties of KICOX:

- Efficient industrial complex management and operation
- Development of industrial complex and expansion of support facilities
- Academia-industry-research cooperation network
- Advance of the support services for tenant companies

6.1.4. Automotive sector

With production of 4.3 million vehicles in 2010, South Korea is world's fifth largest automaker, after China, Japan, the US and Germany. Contributing to 10% of national production, the automotive sector remains a pillar of the Korean economy.

While its initial operations were merely the assembling of parts imported from Japan and the United States, Korea is today among the most advanced automobile-producing countries in the world. In the late 90's, Korean OEMs initiated a major restructuring that enabled them to gain competitiveness and quality. The Korean automobile industry is characterized by the pre-eminence of Hyundai-Kia, the fourth world manufacturer in 2010 (74% of the Korean automotive production). The other producers are GM Korea and RSM (Renault Samsung Motors).
Korea Auto Industries Coop. Association (KAICA)[72] is the only association in the field of automotive industry in Korea. KAICA was founded in 1962 as a non-profit organization for the purpose of the development of Korean automobile and motorcycle industries, especially its parts and components manufacturing industries. Today there are 270 member companies in KAICA. The role of the organization has been to speak for the benefit of the industry, make a proposition to the government and enhance an international cooperation with foreign automotive related organizations.

Today, the Korean government strongly supports the sector with the aim of making South Korea the fifth world supplier at the end of 2012. Achieving this goal involves an intensification of foreign investment in the sector.
Korea also aims to become the fourth largest producer of electric vehicles by 2020. Under the "Green Car Development Act" launched in December 2010 by the South Korean government, public institutions and Korean OEMs multiply the initiatives (R&D expenses, calls for projects, promotion of electric vehicles etc.). In this dynamic, a key asset is the powerful Korean batteries industry, currently No. 1 worldwide.

Green Car Roadmap[73]

[72] Source: http://www.kaica.or.kr/eng/index.php
[73] Source: http://www.greencar.or.kr/eng/

While its auto industry has been busy developing new hybrid and electric vehicle lines, the government of South Korea has announced ambitious plans that include numerical targets for the development of alternative fuel vehicles such as EVs, HEVs, fuel cells EVs (FCEVs), and clean diesel vehicles (CDVs). Collectively, these make up the "green cars" covered by this "green car roadmap".
The government has previously announced its intention of making South Korea the fourth largest manufacturer of alternative fuel vehicles, including electric and hybrids. But in December 2010 it unveiled specific targets.

These targets include achieving by 2015:

- 1.2 million "green cars" annual production, with 900,000 for export;
- Green cars will make up a 21% domestic vehicle market share;
- KRW 3.1 trillion (US$ 2.9 billion) in investment in additional domestic auto industry investment between 2011 and 2015 into achieving the green car roadmap objectives, or more than double the KRW 1.3 trillion (US$ 1.2 billion) invested between 2006 and 2010.

The government is seeking mass production of PHEVs by 2012 and both FCEVs and clean-diesel buses by 2015. The green car roadmap and the targets associated with it are part of a larger set of initiatives to foster the green car industry. Other initiatives include fostering the development of necessary components and supplies to build many vehicles and an expansion of the battery charging infrastructure. As part of its efforts, the government has plans for 1.35 million EV charging points to be built around the country by 2020.
The December 2010 targets built on announcements from 2009 that included introduction of tax incentives of up to KRW 20 million (US$ 18,400) for EV purchasers starting in 2012, plans to build charging stations, provide KRW 400 billion (US$ 368.3 million) on R&D into advanced batteries, and the creation of the On Line Electric Vehicle (OLEV) system by the Korea Advanced Institute of Science and Technology (KAIST) in which EVs are charged inductively by electrical cables embedded in roadways.

6.1.5. National research bodies

National Science and Technology Commission (NSTC)
NSTC is coordination and cooperation regime directly subordinates the Korean president, responsible for the overall planning of R&D and shall coordinate and allocate the R&D budget between different ministries.

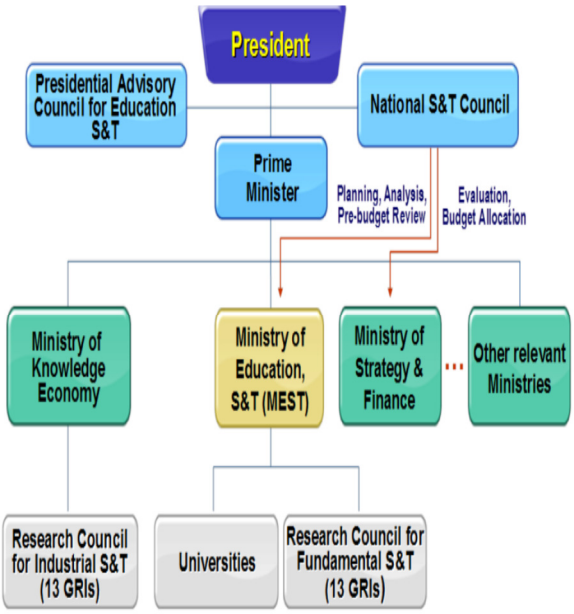


Figure 30: Administrative structure NSTC[74].

Ministry of Education, Science and Technology (MEST)[75]*:*
MEST is responsible for education, science and technology according to the South Korea Science & technology policy. Korea has for many years had a focus on industrialization but for the coming years the new policy indicates that Korea wishes to play a clearer role in the international efforts to contribute to human welfare through the advancement of science and technology. In order to achieve this, the ministry seeks to establish a more balanced innovation system connecting industry, academia and public research organizations.
MEST long term vision for science and technology:

- The major directions for S&T development set out in Vision 2025 include:
- Shift the national innovation system from government-led to private-led
- Improve the efficiency of national R&D investments
- Align the R&D system to global standards
- Meet the challenges and harvest the opportunities presented by new technologies

The Korea Institute for Advancement of Technology (KIAT) [76]is a public institute founded under Article 38 of the Industrial Technology Innovation Promotion Act. KIAT conducts various activities to promote technological policy, including: medium and long-term planning and result analysis; the construction of an industrial technology infrastructure; and the transfer and commercialization of industrial technology.

Major functions:

- Study policy related to industrial technology innovation
- Medium and long-term planning and result analysis related to innovation

[74] Source: http://www.tillvaxtanalys.se/en/index.html?locale=en_US&
[75] Source: www.mest.go.kr
[76] Source: www.kiat.or.kr

- Establishment of infrastructure for industrial technology
- Promotion of regional industries
- Promotion of commercialization and transfer of technology International cooperation.

Incentives:

Investment Support for Hi-Tech or Industry-Support Service Business

- National tax reduction or exemption, Local tax reduction and exemption
- National tax reduction or exemption: 100% exemption from corporate tax and income tax for the first 5 years and 50% exemption for the next 2 years
- Local tax reduction and exemption: 100 exemption from acquisition tax, registration tax and property tax for the 7 years and 50% exemption for the next 3 years

Designation of Foreign Investment Zone

- National tax reduction and exemption, Local tax reduction and exemption
- National tax reduction and exemption: 100% exemption for the first 5 years, 50% exemption for the next 2 years
- Local tax reduction and exemption: 100% exemption for the first 7 years, 50% exemption for the following 3 years
- Further support: infrastructure (Road, water and electricity)
- Exemption from the traffic generation charge

Free Economic Zone (FEZ):
A FEZ is an area specially designated to provide companies with an optimal environment to engage in global business activities.

- A cluster of global companies is formed by providing advanced socio-economic systems and diverse incentives.
- World-class cities are built through development of cutting-edge airports, ports and office facilities as well as high quality schools, hospitals and tourist facilities

Support for Human Resource Development to Attract Foreign Invested R&D Centres
Human Resource who charge with whole R&D:

- Subject: persons with (or expect to have) bachelor's degree or more in field of science and engineering
- Period: for 2 years from the time of employment
- Support limit: within 80% of eligible human resource annual salary, up to KRW 30 million per person
- Human resource of education and training:
- Subject: education and training staffs sent from foreign countries
- Support limit: within 50% of stay expenses, up to KRW 50 million per person

6.2. DAEJEON REGION

The following description of the regional research and innovation eco system within green and safe is provided by a representative from the SAGE partners situated in Europe but with a Korean background and local contact connections to the area of Daejeon.

6.2.1. Background information

The population of Daejeon has been increasing over the past 4 years. Industrial complex growth with government funding support has been the main reason for the change. Most of the new generation prefer to stay focused around the metropolitan area, however Daejeon has shown another potential for the new generation as to take advantage of the infrastructure that it provides with lower cost living and an advanced quality of living compared to Seoul area. The ease of education facility reach and quality of the school itself has been of the main concerns; however KAIST has been named as one of the leader in engineering & science and has proved its advanced educational level over the past years resulting in the top engineering school these days.

Transport and infrastructure

Daejeon is a center of transportation in South Korea, where two major expressways, Gyeongbu and Honam, and two major railways, Gyeongbu and Honam are joined. Travel time between Daejeon and Seoul using the high-speed train, otherwise known as KTX, is about fifty minutes. The nearest airport to Daejeon is Cheongju Airport, about a thirty-minute drive north of Daejeon.

Competitiveness and economy

In 1974, the Daedeok Research Complex was founded as to broaden the Science and Technology for the nation. This served as the seed effect of Daejeon to be the city of science and technology today. 1980 was a year of change in Daejeon when more than 10 government established facilities were located in the area. Daejeon has been the rapid growing city since then in South Korea.

Daejeon at a glance:

Population: 1,5 million inhabitants

Area: 539.85 km^2

GRDP: US$1014 billion in 2010

Key industrial technologies: Automobile, Shipbuilding, Semiconductor, IT, Display, Machinery & Manufacturing

Daejeon has been focusing on export for the past years and made significant difference increasing the profit from export and at the same time reducing the import dependencies. Recently, majority of the raw materials were heavily dependent upon the Japanese. However, with the development for the advanced engineering, the dependencies on foreign countries have decreased. Major profit was taken from the semi-conducting business in the past but bio, medical, energy and materials have been serving as the growing market in technologies. Not only the actual manufactured products have been selling well but also the technologies were carried out for different application which paid back with consulting in the industry and academia.

6.2.2. Regional innovation system

This chapter describes the various players of the cluster and regional systems to support innovation.

Industry

KARI (Korea Aerospace Research Institute)[77] is one of the eye catching research centre located in the Daedeok research complex. KARI performs basic and applied studies in aerospace technology as well as government-delegated tasks and support policy development. In addition, KARI support industries and transfer technology. When working with the industry, KARI performs joint utilization of testing facilities and equipment as well as training scientists and engineers.
Various types of research are being held at KARI from aircraft, helicopter to aerospace and rockets. Recently, efforts are heavily involved with the satellite and advanced materials.

KATECH (Korea Automotive Technology Institute)[78] is located in Cheonan. It was established in 1990 to innovative technology development for the Korean automotive industry. Distribution of automotive technology for the industry as well as contribution to the technological achievement and competitiveness of the industry is the main aim for its existence. Since its foundation, KATECH has been setting the standard in the Korean automotive industry and expanded its facility dramatically.
The research and development categories at KATECH are listed in four different topics; Green car powertrain, Intelligent vehicle technology, Materials and components and Corporation support and reliability.

1. Green car powertrain

   The green car powertrain system R&D centre is a leading globally throughout the world in automotive components market and its materials for future power systems. The centre focuses on the existing combustion system and the next – generation engines. The following are research areas that are investigated:
   - Advanced Powertrain System Technology
   - Advanced Combustion Technology for High Fuel Economy and Low Emission
   - Engine and Powertrain Control Technology for Green-car
   - Development of Fuel Economy and Emission Performance of Engines for Green-car
   - Downsizing Technology for Engine
   - Automotive Technology with Next Generation Alternative Fuel System
   - Development of Fuel System and Combustion Technique for Alternative Fuel Engines

[77] Source: http://m.kari.re.kr/eng/html/about/info.html
[78] Source: http://www.katech.re.kr/eng/open_contents/sub01/0101.html

- Analysis and Evaluation of an Automotive After treatment System
- Development of Control Algorithm and Performance Optimization for after treatment System
- Performance Test and Evaluation Technique of Engines; for Green-car
- ECU Development and Engine Mapping Techniques
- Vehicle Optimization of Fuel Economy and Emission
- Optimization for Engine Component parts
- Technical Supports for small and medium Businesses

2. Vehicle-IT fusion technology centre

This department is dedicated to the development of Vehicle – IT Fusion Technology for enhanced and higher value-added vehicle based on vehicle network, digital map and embedded system technologies. Following are their research areas:

- ITS/Telematics Core Technology
  - IT Fusion based Vehicle Safety • Convenience improved Technology.
  - Multi-modal Transportation System and Vehicle Service Technology.
  - ITS/Telematics Device and Service Technology.
  - Vehicle Network and Simulation Technology.
  - ITS/Telematics Communication Test and Certification.
- Green car IT Fusion Technology
  - Green-IT based Vehicle Control Technology.
  - Electric Bicycle Core Components and Control Technology.
  - IT based Vehicle and Components Reliability Test Technology.
- Digital Map Technology for Vehicle Application
  - Digital Map Construction and Application Technology.
  - Vehicle Positioning and Application Technology.
  - Map based Driver Safety Assistance Technology.
- Vehicle Embedded Software Technology.
  - Vehicle Electric Control Device Design Technology.
  - Vehicle Software Test Technology.

3. Environmental materials and components R&D centre

The team supports the green growth of the automotive industry. In other words, supporting environmental friendly components and materials for energy saving and conversion as well as for environmental improvement and cleaning. Following depicts their research areas:

- Ceramic, Polymer, Light Materials and Components
- Fuel Cell, Environment and Energy Related Technology
- Composite/Nano Materials and Components
- Environmentally Friendly Materials and Recycling Technology

- Surface Treatment, Powder Synthesis and Thin/Thick Film Manufacturing
- Design, Process and Analysis Technology For Automotive Materials
- Interior & Exterior Components and Highly Sensitive Automotive Components
- High Emotional Sensibility Components
- Materials Technology for Automotive module

Test and assessment capabilities are listed below:

- Characterization of Organic, Inorganic and Metallic Materials
- Thermal/Mechanical Test of Automotive Components
- Reliability/Durability Test of Automotive Components
- Fuel Cell Components Test and Performance
- Coating and Characterization of Thin/Thick Film
- Molding and Characterization of Polymer

4. Electronics reliability research centre

Building a basis for reliability assessment for domestic manufacturers which leads to global standard for automotive parts is the main mission for this department.

- Acquire and Operate Reliability Assessment Equipment
- Development and Establish Reliability Assessment Standard
- Reliability Certification of Licensed Products Category
- Establishment of Reliability Improvement Technology Support System
- Life Evaluation of Green car Parts
- Virtual Test Analysis
- Design and Verification of Acceleration Test for Electronics Reliability
- Adopt International Class Reliability Assessment Technique
- Construction of data base for assessed products
- Evaluation and Analysis of test, reliability, and failure assessment, high accelerated life tests, and life prediction. Various equipment and soft wares are set for different types of research.

Universities and research institutes

KAIST (formerly the Korea Advanced Institute of Science and Technology)[79]**,** is located in Daedeok Innopolis, Daejeon, South Korea. KAIST was established by the Korean government in 1971 as the nation's first research oriented science and engineering institution. KAIST was founded with government funding and was initially staffed with a number of Korean engineering and science talents educated in the United States. From the onset, the emphasis has been in theoretical as well as applied research. KAIST continues to be Korea's foremost centre of strategic research and development (R&D) projects. The University helped

[79] Source: http://www.kaist.edu/edu.html

pioneer the establishment of competitive research oriented graduate school programs in Korea.

The University's some 540 faculty conducts research in cooperation with academies and industries all over the world. KAIST offers grants and fellowships to international students. KAIST president, Nam Pyo Suh, is an authority in axiomatic design technology. Soon-Heung Chang, a nuclear scientist, serves as provost and Ji-won Yang, a chemical engineer, as vice president for external affairs. The University has for many decades, recruited faculty from overseas. Current president Nam Pyo Suh taught for many years at MIT. His predecessor, Robert Laughlin, a Nobel laureate and a physics professor at Stanford University, was the first non-Korean to head a Korean university. The vast majority of professors come from US higher education institutions. The school engages in many international programs with leading European and Asian universities. The university is a member of LAOTSE, an international network of universities in Europe and Asia. It is also a member of the Association of East Asian Research Universities. Over the past 30 years, KAIST has produced 8,453 bachelors, 17,762 masters, 6,726 doctorate holders (doctors under 30 years of age were 2,920, 43.4%) giving a total of 32,941 alumni. The thesis published in SCI (US, Science and Technology Quotation Thesis Search) journals reached approximately 4 articles per each faculty member, and the commissioned research grant was approximately 200 million won per each facility, which is world-class level.

There are 6 colleges, 2 schools, 21 departments, 3 divisions, 6 professional graduate schools and 10 interdisciplinary programs. Researchers at the Korea Advanced Institute of Science and Technology (KAIST) have developed an electric transport system (called Online Electric Vehicle, OLEV) where the vehicles get their power needs from cables underneath the surface of the road via non-contact magnetic charging, (where a power source is placed underneath the road surface and power is wirelessly picked up on the vehicle itself. As a possible solution to traffic congestion and to improve overall efficiency by minimizing air resistance and so reduce energy consumption, the test vehicles followed the power track in a convoy. In July 2009 the researchers successfully supplied up to 60% power to a bus over a gap of 12 cm (4.7 in) from a power line embedded in the ground using power supply and pick up technology developed in-house.

Governmental and other public organizations

South Korea has no petroleum on its natural resource list meaning no oil production within the country. Since 20 % of the country's energy consumption accounts by the transportation sector, "Low Carbon-Green Growth" has been stated as the technology motto since October 2009 by President Lee Myung-Bak. Mass production of EV (Electric Vehicle)s became the national main project to align with the global environment regulation as well as protection on the high fuel prices.

With the national goal set to focus on the EVs, relevant ministries and government agencies were deeply involved in EV development plans. The industry and academia along with research institutes leaned toward to set the main goal for EVs. MKE (Ministry of Knowledge Economy) is responsible for the EV supplies expansion and has launched "Green Car Forum" with government specialist, university experts and different business sectors to establish meaningful strategies in developing and commercializing the environmentally-friendly vehicle.

Since the announcement from the government, civil department began to designate the driveways for EV; different retailers considered building charging stations and automotive manufacturers initiated mass production preparation on EVs.
The South Korean government has announced a FSEV (Full Speed Electric Vehicle) promotion plan which includes 1 million EVs by the year of 2020. The program aims to become the 4th largest EV market. Technology project for strategic development of clean Diesel car components industry, clean Diesel National Assembly Forum and the 2010 Green Car Forum proves its intention.

Barriers to deploy the EVs fully includes high battery price which is approximately 50% of the vehicle cost and long battery charging hours that requires over 7 hours at 220V. However, the government will invest large portion of the difficulties in different eco-friendly automotive development areas as to increase the quota of more than 10% by 2013. Currently, the government supports up to 3.1 million KRW through tax reduction on hybrid vehicles. As for EVs, various support schemes are under consideration and will be adapted.
Seoul which is the metropolitan city of South Korea had a plan to invest 10.9 billion KRW on "Green Cars" for public transportation on buses, two-wheelers and different EV infrastructures.

The movement of Seoul city is moving south and Daejeon is directly influenced by the trend. Especially, Daejeon city is where most of the research centre is located that aim for the EV category development. In Daedeok research complex, both the academia and industry is located closely for better collaboration as well as efficient communication which the government has intentionally managed since its construction.

6.2.3. Technology competence & economic ability of the cluster

Looking at the main players for automotive, Hyundai-Kia, GM-Daewoo, Renault-Samsung Motors and Ssang-Yong Motors may be the local companies. Hyundai-Kia is the only existing domestic company who shares majority of the market demands. The other players are non-competitive in terms of volumes. Since Hyundai-Kia is the main company who leads the volume and the technology, suppliers and research centres are focusing on their direction.

Variety of projects from Hyundai-Kia is collaborated throughout the nation; however the core technology for the future application is more focused in Daejeon's research complex starting with KAIST and other industry partners. LG Chemical, SK Energy is to name a few. Recent development has steered the direction for inverters, batteries, motors, telecom, chargers and infrastructures. One of the main organizations on the technology part for automotive engineering is performed at KATECH.

Though petroleum gas and other alternative fuels such as LPG and CNG are used, recent movement toward EVs has been focused in the research institutions. Not only the vehicle itself but the system, social infrastructure and the derived industrial outcome have been of interest in the different organization within Daedeok research complex.
The biggest difference with the other cluster on research is that it is purely research based projects from the start. Having less squeezes from the field, ideas and application thoughts are assembled for prototypes and is extensively supported by the government.

Since the Daedeok research complex is superior in its location which is close to the metro area as well as having all the different industry partners located close by, expedited collaboration opportunities are there among the academic forces for the development.

6.2.4. Cluster organization management – technological focus and organizational capability

Public funding opportunities

At the beginning of each year, the government releases various categories on technology development. Different topics are open to the public and there is no restriction to apply for a proposal. Basically, the public announcement as well as the RFP (Request for Proposal) is listed on-line and it is the applicants' responsibility to monitor and pick up the current events Table 6 lists the on-line URLs which are locally known among business sectors.

Name (English)	URL	Location & Contact
Total Technology & Development Business Management System for Small – Medium Sized Enterprises	www.smtech.go.kr 중소기업청 기술개발사업 종합관리시스템	Seoul & Daejeon Phone: 1661-1357
Korea Evaluation Institute of Industrial Technology	www.keit.re.kr Keit 한국산업기술평가관리	Seoul & Daejeon 02) 6009-8000 042) 715-2114
Korea Institute for Advancement of Technology	www.kiat.or.kr KIAT 한국산업기술진	Seoul 02) 6009-3000

Table 6 On-line Posting Bulletin Board on Public Funding Opportunities

Once the government identifies the potential projects they are formulated into different research and development strategies and announced into the public sectors. New applicants will call for the topic and the most potential projects are selected after strict review and interviews. Normally, most of the contracts are for 3 ~ 5 years and it takes about 6 months until the final decision for the award winner.

Figure 31 depicts the 2012 total governmental R&D budget in South Korea. Approximately 31% is dedicated to Science & Technology of the whole budget.

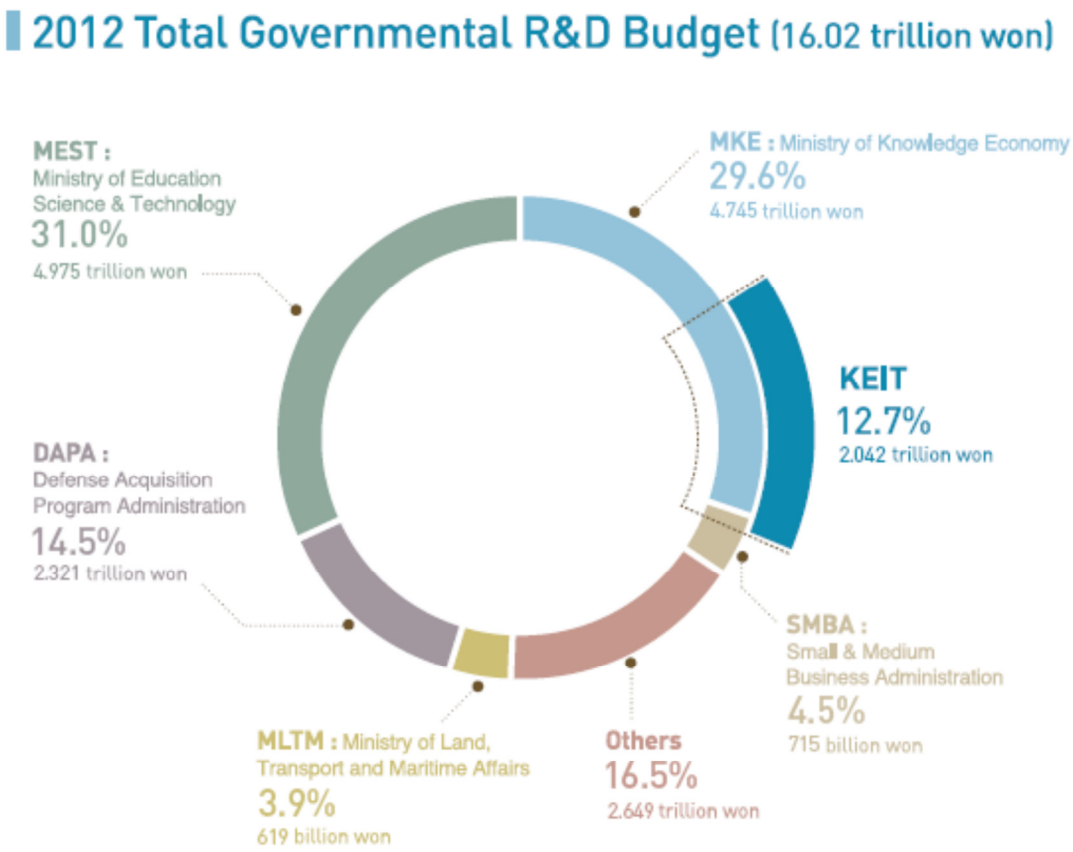


Figure 31: 2012 Government R&D Budget

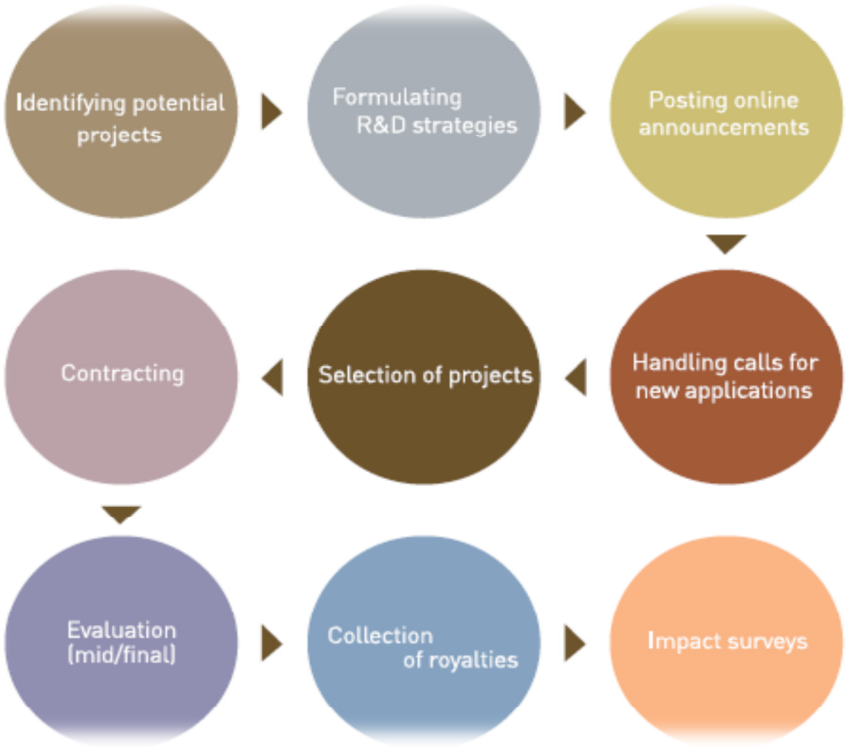


Figure 32: Operational Process

Seoul which is the metropolitan area in S. Korea is the main role in the administrative part for the work flow. However, in parallel Daejeon is selected as the branch office for Seoul that is closely located where the technologies are invented and being developed. In addition to the comfort of the location, quite a few conferences and meetings are held in Daejeon. For example, “The 3rd Innobiz Global Forum 2012” will be held on May 23rd and 24th, 2012 in DCC (Daejeon Convention Centre). Figure 4 shows the front title of the Innobiz global forum this year.

Figure 33 : Innobiz Global Forum 2012 http://www.innobizglobal.org/partnering/info_eng.php

In following section the document will address current announcement for machines and materials for a quick view on the hot topics that S. Korea is aiming for.

Current Announcement on Smtech - As of April 20th, 2012 http://www.smtech.go.kr/front/main/main.do

[전체과제총계: 25,920건]

주요분야	세부분야(과제수)
기계 · 소재 Machine & Materials	정밀생산기계 (421) | 자동차/철도차량 (671) | 에너지/환경 기계시스템 (989) | 요소부품 (758) | 로봇/자동화기계 (546) | 산업/일반기계 (948) | 조선/해양시스템 (271) | 항공/우주시스템 (74) | 나노 · 마이크로 기계시스템 (192) | 금속재료 (323) | 주조/용접 (305) | 소성가공/분말 (204) | 표면처리 (330) | 청정생산 (100) | 정책과제(과거) (0) 총 6,129 건
전기 · 전자 Electric & Electronics	광응용기기 (482) | 반도체장비 (491) | 중전기기 (520) | 반도체소자및 시스템 (224) | 전기전자부품 (660) | 가정용기기및전자응용기기 (569) | 계측기기 (582) | 영상/음향기기 (349) | 전지 (88) | 디스플레이 (373) 총 4,338 건
정보통신 IT	이동통신 (250) | 디지털 방송 (47) | 위성-전파 (71) | 홈네트워크 (298) | 광대역 통합망 (309) | RFID/USN (76) | U-컴퓨팅 (275) | 소프트웨어 (1,265) | 디지털 콘텐츠 (608) | 지식정보보안 (252) | 정보통신 모듈 및 부품 (439) | ITS/텔레매틱스 (89) 총 3,979 건
화학 Chemical	정밀화학 (764) | 고분자재료 (571) | 화학공정 (103) | 화학제품 (431) | 대기/폐기물 (304) | 수질/토양 (215) | 세라믹재료 (326) | 섬유제조 (157) | 염색가공 (134) | 섬유제품 (220) 총 3,225 건
바이오 · 의료 Bio & Medical	의약바이오 (431) | 산업바이오 (678) | 바이오공정/기기 (123) | 치료기기 및 진단기기 (408) | 기능복원/보조 및 복지기기 (273) | 의료정보 및 시스템 (50) 총 1,963 건
에너지 · 자원 Energy & Resources	온실가스처리 (5) | 자원 (6) | 수화력발전 (9) | 송-배전계통 (10) | 전력IT (16) | 원자력 (5) | 신재생에너지 (200) | 에너지효율향상 (0) 총 251 건
지식서비스 Consultation	경영전략/금융/무역서비스 (5,864) | 연구개발/엔지니어링서비스 (39) | 인적자원 역량개발서비스 (15) | 유통/물류/마케팅서비스 (19) | 부가가치/사후관리서비스 (30) | 디자인 서비스 (51) 총 6,018 건
기타	기타 (17) 총 17 건

The red square indicates;

Category	Topics Announced
Precision Manufacturing Machine	421
Automotive / Trains	671
Energy / Environmental Mechanical	989

System	
Machine Elements	755
Robots / Automation Machines	546
Industrial Machines	948
Vessels / Marine System	271
Aerospace / Aircraft System	74
Nano / Micro System	192
Metallic Materials	323
Casting / Welding	305
Sintering / Plastic Machining	204
Surface Treatment	330
Eco Production	100

Table 7 : Current Announcement "Machines & Materials"

From Table 7, it is evident that the topics are focused on Ground Transportation, Energy and the processing machine technologies that can enhance the aforementioned two categories. Trucks, automotive as well as bus and construction equipment are all thought to be included in the automotive / trains section. The second outstanding topics cover processing technologies which are one step further from the current manufacturing methods. Materials and coating technologies are also an area of attention. Aircraft and aerospace on the other hand shows the least topics announced and this is thought to be the reason since S. Korea does not have their own brand in the aerospace industry but rather act as one of the supplier to Boeing or Airbus.

6.2.5. Summary Daejeon

S. Korea has developed various types of technologies in the past at a high speed pace. There are factors lying behind those accomplishments as to present the regional advantages as well as the enthusiasm and the collaboration between academia and the industry. It is therefore worthwhile to investigate how the process is being built within different clusters in S. Korea.

Daejeon was selected to be the cluster of interest in S. Korea because of several reasons. Most of the industry research centres as well as the national labs are located in Daejeon. A research complex called “Deadeok Research Complex” is established early 90’s for the development acceleration among academia and industry and have been showing tremendous progress in the last decade. In addition to this, public funding agencies are placed within the area which even possesses the larger possibility for networking and different conferences and consortiums. Compared to the Busan cluster where Hyundai Motors are the main players, Daejeon is represented by the new technology driving force and Busan as the automotive industry leader.

New technologies are mainly developed by the initiation from the government announcement which is normally taken place annually at the beginning of the year. RFPs are placed with no restriction for the application. However, recent movement has shown that exceptional credits have been applied to the proposals which include collaboration among the industry and the academia together. The reason behind this is to keep the education enthusiasm in the loop as well as to focus the technology more practical. Based on the recent announcement by the S. Korean government, it was evident that majority of the budget was dedicated to increase the technology in the area of ground transportation as well as in processing techniques. Fundamental research interest in Nano scale is also not to be overlooked.

Aside from the public funding process, it is very important how the small and medium sized companies are working with their OEMs. Majority of the small and medium enterprises do not have the ability for characterization or prototyping due to initial high cost investment. However, the process that are to be explored is how major companies and their suppliers take advantage each other which at the same time receives support from the government satisfying the grant conditions.

As an additional reminder Samsung, Hyundai, LG and SK who are the large companies in S. Korea have their own sister companies within the boundaries and have full control on them. For example, Samsung Electro-Mechanics (SEM) is part of Samsung Electronics (SEC) company but a supporting team. They produce modules that are part of the SEC final product and even export or sell their modules to other customers.

6.3. BUSAN/ULSAN REGION

The following description of the regional research and innovation eco system within green and safe is provided by a representative from the SAGE partner's organizations and is carried out mainly through desk-top research from a distance.

6.3.1. Background information

Busan[80]

Busan (Officially Busan Metropolitan City), is South Korea's second largest metropolis after Seoul, with a population of around 3.7 million. Located at the south-eastern tip of the Korean Peninsula, Busan has served as Korea's gateway to the world since its opening as an international port in 1876. As a critical link between the Pacific and the Eurasian Continent, Busan also has become a major logistics hub, ranked as world's 5th largest container port.

Busan at a glance:

- **Population:** 3,7 million
- **Area:** 763 km²
- **GRDP:** approx. US$ 50 billion
- **Major industry**: Port logistics, auto parts and materials, convention and tourism, film and IT, finance. World's 5th largest container port

Key Point in World Logistics:
Busan is a strategic point in world logistics, as it is a major port on the North American and European trunk routes. Furthermore, Busan is the future starting point of transcontinental railways that will run from Korea through China and Russia, all the way to Europe

World's 5th Largest Container Port:
Busan is Korea's No. 1 port city, and 75% of all container cargo coming in and out of Korea is processed in Busan. Its container throughputs have consistently grown, placing Busan among the world's top five container ports since 1995. With the opening of Busan New Port with 30

[80] Source: Busan Metropolitan City Homepage: http://english.busan.go.kr/index.jsp

additional berths by 2015, Busan is well-positioned to grow into a global port and a logistics hub of Northeast Asia.

Centre of Korea's Southeast Economic Belt:
Busan serves as the economic and logistics hub of Korea's Southeast Economic Belt, where Korea's leading industries are located. A total of 50% of national output in shipbuilding, 90% of ship parts, 45% of automobile, 40% of machinery is produced in the region

City of International Convention and Tourism:
Busan is also known as a city of international convention and film festivals, recognized as one of "Top 10 Asian International Convention Cities" by UIA. Busan proved its capacity as a global convention city by successfully hosting a series of major international events such as 2002 Asian Games, 2002 FIFA World Cup, and 2005 APEC Summit Meeting. Pusan International Film Festival (PIFF) has grown as Asia's biggest film event in just 10 years.
Busan's attractive natural environment combining beaches, rivers, and mountains allows the city to take up more than 30% of all Korea's tourism industry and presents a unique opportunity to become an international tourist hub.

Ulsan[81]



Ulsan (officially the Ulsan Metropolitan City), is South Korea's seventh largest metropolis with a population of over 1.1 million. It is located in the south-east of the country, neighbouring Busan to the south and facing Gyeongju to the north and the Sea of Japan to the east.
Ulsan is a de-facto "capital of Korean industries", responsible for 12.6 % of the nation's industrial production and exports worth over US$ 55 billion.
The City has Asia's representative industrial cluster, which includes key industries like automobile, shipbuilding and petrochemical, and growth industries of the 21st century.
Ulsan is the industrial powerhouse of South Korea, forming the heart of the Ulsan Industrial District, which is home to the world's largest automobile assembly plant operated by the Hyundai Motor Company, the world's largest shipyard operated by Hyundai Heavy Industries and the world's largest oil refinery, owned by SK Energy.

Ulsan at a glance:

- **Population:** 3,7 million
- **Area:** 763 km²
- **GRDP:** approx. US$ 50 billion
- **Major industry:** Port logistics, auto parts and materials, convention and tourism, film and IT, finance. World's 5th largest container port

[81] Source: http://en.wikipedia.org/wiki/Ulsan

Strategic Stronghold for the Industry in Northeast Asia:
Ulsan is a central city in the southeast industrial zone of Korea. Its favorable geographic location that links oceans and continents offers easy access to many surrounding countries. In addition, the city is reachable within a 2-hour flight from major cities in East Asia such as Beijing, Shanghai, Hong Kong, Tokyo and Osaka proving it to have the best location as a strategic stronghold for many industries

Hub of Industrial clusters in Korea:
Ulsan is at the heart of the most advanced industrial cluster. Steel, machinery and port service industry clusters are formed in Pohang, Busan, Masan and Changwon all of which are a one-hour drive away from Ulsan. They help Ulsan's key industries such as automobile, shipbuilding and petrochemical industries accumulate more active and innovative synergy than any other cluster in the world. The industrial cluster in Ulsan is considered to be the best among those of its kind in Asia. It offers various business opportunities and an attractive investment environment.

Administrative support:
Ulsan city provides support for foreign companies starting from choosing their factory site, registering their businesses and employing workers by assigning project managers to each company, so that they can smoothly settle in Ulsan.

History of the region:

From the beginning of the 15th century, the Korean government designated Busan as a trading port with the Japanese and allowed their settlement. Other Japanese settlements in Ulsan and Jinhae diminished later, but the Busan settlement, called Waegwan at the time, continued until Japan invaded Korea in 1592. After the war, diplomatic relations with the new shogunate in Japan were established in 1607, and Busan Waegwan was permitted to be reconstructed. The Japanese settlement, though relocated into Choryang later, continued to exist until Korea was exposed to modern diplomacy in 1876. In 1876, Busan became the first international port in Korea.

During the Japanese rule, Busan developed into a hub trading port with Japan. Busan was the only city in Korea to adopt the steam tramway before electrification was introduced in 1924.

During the Korean War, Busan was one of only two cities in South Korea not captured by the North Korean army within the first three months of the War, as a result the city became a refugee camp site for Koreans during the war, along with Daegu.

As Busan was one of the few areas in Korea that remained under the control of South Korea throughout the Korean War, for some time it served as a temporary capitol of the Republic of Korea. UN troops established a defensive perimeter around the city known as the Pusan Perimeter in the summer and autumn of 1950. Since then, like Seoul, the city has been a self-governing metropolis and has built a strong urban character.

In 1963, Busan separated from Gyeongsangnam-do to become a Directly Governed City (Jikhalsi). In 1983, the provincial capital of Gyeongsangnam-do was moved from Busan to Changwon.

In 1995, Busan became a Metropolitan City (Gwangyeoksi).

In June 2005, the Korean government announced a decentralization plan according to which 176 public institutions were relocated outside the capital region and Daejeon to 12 regional metropolitan cities. The relocation project prompted Busan city to construct a future-oriented, region-specific city where local industries, academia, research institutions and local autonomous organizations work together to foster regional growth.

They take examples of successful Innovative City project such as Sophia Antipolis in France, Toyota City in Japan and Kista in Sweden, all of which managed to enhance their regional and national competitiveness through the project.

Busan Innovative City consists of three innovation districts and a multi-dwelling residential area once other agencies are relocated: four agencies related to maritime and fisheries will be relocated to the Dongsam district, three film-related agencies to the centum district, and six financial and other public institutions to the Munhyeon district.

Automotive History:

In 1968, Hyundai Motor Company established manufacturing facilities in Ulsan, and it was the very beginning of development of Ulsan automobile cluster. At that time, the company traded on about 50 part supply companies, which were mostly located in the capital region. In 1975, the Hyundai Motor Company established its production line on a scale of 80,000 annually, and shifted its production method. Its production capacity was remarkably improved. As a result, the production infra for automobiles has been developed. Many parts-supply companies, including Sejong and Dukyang, have established their factories in Ulsan since mid-1970s. Continually other related companies have located in the region. Therefore Ulsan automobile cluster has been successfully formed.

6.3.2. Regional innovation system

This chapter describes the various players of the cluster and regional systems to support innovation.

Ulsan area – Ulsan Onsan National Industry Complex

Category	Ulsan Onsan National Industrial Complex
Purpose of establishment	Large-scale petroleum refining, petrochemical, automobile, and shipbuilding industry-related industrial complex
Size	65,353,000 m²
Tenant companies	1,195 companies
Industry types	Petrochemical (54.1%), **Automobile (17.0%),** Shipbuilding (15.9%), Other (13.0%)
Estimated production	99,693 million dollars (Estimation for 2011)
Main industries	**Automobile,** oil, shipbuilding
Complex characteristics	• It is the nation's largest industrial complex with an industrial structure that is focused on the automobile, shipbuilding, and petrochemical industries. • Automobile industry: Has an annual production capacity of 1.6 million. Accounts for 34% of domestic production of finished cars (4.7 million cars) (location of Hyundai Motor's Ulsan Plant). Around 120 parts suppliers

	moved into the complex. • Petrochemical industry: Around 190 companies moved into the complex, including two crude oil refining companies - SK and S-oil - and companies that supply half-finished products to the two companies mentioned above.

Characteristics of the Ulsan Cluster:
Cluster of around 120 small- to mid-size parts suppliers, mainly those in the fields of automobile interior parts, car body, and chassis (Small companies with less than 50 employees each account for approximately 50%)

There is a lack of independent enterprises of middle standing because of a high level of dependence on a finished car company (Hyundai Motor).

Hyundai Motor's Central Research Institute relocated to the metropolitan area. As a result, its partner companies also moved to the area. There is a lack of research personnel and capabilities at corporate research institutes located in regional areas.

Participating organizations and companies of the Ulsan Cluster:
Company: Around 100 companies, mainly partner companies of finished car manufacturers

University: University of Ulsan, Ulsan National Institute of Science and Technology (UNIST)

Research institute: Research Institute of Industrial Science & Technology (RIST)

Organization: Ulsan Techno park

Technology areas of the Ulsan Cluster
Mini-Cluster (MC)*: This is a consultative body that consists of industry, academia, research, and government officials and is related to a specific industry type or technology area. Members of a consultative body routinely and continually engage in mutual cooperation, joint learning activities, and information-sharing activities. It is participated in by mainly companies as well as parties that take the lead in innovating a regional area, including universities, research institutes, and supporting organizations. The mini clusters are a part of the Industrial Cluster Competitiveness-Strengthening Project (Industrial Complex Cluster Project) of the Korea Industrial Complex Corp.
Production Base MC: Base industry (root industry) for manufacturing of automotive parts. Leading companies: HANGUKMOLD, SIS

PT chassis MC: Automotive parts manufacturing and module industries. Leading companies: KOFCO, Dongnam Group, Hanjoo Metal

Green materials and parts MC: Chemical industry related to automotive parts and materials. Leading companies: M.DOHMEN Korea, Taesung CNC

Busan area - Noksan National Industrial Complex

Establishment and size	Operation status

- Establishment: Year 1990 - 2002 - Area: 6,972,000 m² - Tenant companies: 1,508 companies	- Production: 11.6243 trillion won - Exports: 2,489 million dollars - Employment: 34,019 persons

Table 8 : General status as of December 2011

Characteristics of the complex:

Located at the centre of industrial belts in the southeastern region : Connects Yeosu, Gwangyang, Geoje, Changwon, Gimhae, Yangsan, Ulsan, Pohang, and other areas. As a cluster of small- to mid-size companies, it mainly consists of companies that are in the growing phase (Small companies whose number of employees is no more than 50 persons each account for more than 90% of the total). There is a high degree of specialization in shipbuilding equipment and automobile/machinery related parts and materials (Outstanding basis for clustering of machinery parts and materials industries). There is a high degree of industrial agglomeration by industry type with the move-in of six 'collaborative business sites': Shipbuilding and marine equipment, wind power, plating, shoes, dyeing, leather, etc. The tenant companies' R&D competencies and capital structure are weak. This is why the companies are focused on low value-added tall processing activities.

Business type	Status
Shipbuilding and marine equipment	• Strengths in such fields as deck, heat exchanger, and engine parts (Korea's largest cluster) • Focus on developing high value-added vessel parts, including offshore plants and LNG vessels
Parts and materials	• Has items that lead the global market, including forging equipment, bend, and wind power generation facility • There is a need for continued investments in R&D on market-leading items
Electricity and electronics	• Sharply growing with an expansion in R&D investments and technological development capabilities • Aiming to become the world's best with focus on mobile phone parts and semiconductor inspection equipment
Automotive parts	• Located near Renault Samsung Motors • There is a need for concentrated investments in the development of high value-added parts
Plating	• There is a need for increase in demand and advanced technologies across various sectors • The companies are small and substantially lack internal R&D capabilities
Shoes	• Continuing a downward trend in tandem with a drop in the relative importance of the industry and price competitiveness • Striving to advance forward again by developing new technologies and producing specialized products

Characteristics of the Busan Cluster:

Execution of the cluster project

- Commencement of project: April 2008
- Operation of Mini-Clusters: Four (Shipbuilding and marine equipment, parts and materials, plants, and new & renewable energy).
- Participating companies: 200 companies (Experts: 35 persons)

Establishment of a cluster that is focused on the shipbuilding equipment industry, which has traditionally been a strategic industry, as well as the offshore plant and wind power generation parts industries, which are new growth drivers.

- Promotion of the offshore plant industry: Foster into a new growth driver that will replace the general-purpose shipbuilding equipment industry.
- Focus is placed on fostering future industries for green growth such as wind power generation parts and nuclear power generation parts.

The degree of agglomeration is relatively lacking in case of the automotive parts industry. In addition, the automotive parts industry does not account for a large portion of the cluster.

Participating organizations and companies of the Busan Cluster
Cluster of research institutes in the complex and nearby areas (10 kilometres):

- Busan Techno park
- Korea Institute of Industrial Technology (South-eastern area headquarters)
- Korea Marine Equipment Research Institute
- Research Institute of Medium & Small Shipbuilding
- Korea Basic Science Institute

Moving forward with a project to establish an industry-academia convergence district and is working on becoming designated as a special R&D district: Public invitation-based project of the Ministry of Knowledge Economy. Maintaining close cooperative relations with local universities: Pusan National University, Korea Maritime University, Tongmyong University, Pukyong National University, and other universities. Companies with registered affiliated research institutes: Approximately 90 companies including DongHwa Entec. Venture companies and INNOBIZ certified companies: 110 companies including Korinox.

Central government or local government support policies:
Korea Industrial Complex Corp. provides support for industry, academia, and research sectors and for the establishment of a network through the cluster project.

South-eastern Area Leading Industry Support Team: Focused on fostering the offshore plant industry.

Busan Metropolitan City: Planning to actively foster the new & renewable energy industry, including wind power generation parts.

Industry

OEMs:

Hyundai Motor Company

Hyundai Heavy Industry

Renault Samsung Motors

SsangYong

Daewoo Bus (General Motors)

Volvo

Tier1 suppliers:

Continental

Bosch

Denso

Samsung SDI

Mobis (Hyundai Group)

Faurecia

Valeo

Plastic Omnium

Brüel & Kjær's

Mobil

DUPONT

Other suppliers:

Posco (Pohang Iron and Steel Company)

SK global chemical

SK Energy

Dassault Systems

Most of the enterprises in the cluster are closely related to Hyundai Motor Company

Major auto-parts makers located in Ulsan are 286 companies including Hyundai Mobis, Duckyang Industry, Sejong Industrial Company, and there are about 350 auto-parts providers located near Ulsan to deliver products to Hyundai Motors and Daewoo Bus.
The city forms South Korea's largest industrial cluster, connecting the automobile, ship building, and petrochemical industries

Busan-Ulsan cluster is an industrial cluster. The activities focused mostly on production, rarely on R&D. The automotive activities in Ulsan region are mainly focused on Hyundai while the automotive activities in Busan region mainly are focused on RSM. Main focus of research for both areas are e.g. new processes, new materials, vehicle electrification and ITS.

Academia

Universities:

Busan National University of Education

Pusan National University

Pukyong National University

Korea Maritime University

University of Ulsan

Postech (Pohang University of Science and Technology)

Universities in Busan and Ulsan, as in other regions, have contributed significantly to regional development by raising qualified and highly-skilled human resources. At the same time, they have carried out research and development that support the businesses in the region.

Busan Techno Park has been established, and since 1995 three regional research centres have been active. In both the Techno Park and the research centres, the Universities and their researchers perform important roles.
In Korea, Universities became central vehicles of regional development in large part with efforts made by the government as the current administration took over in 2003. The 'Participatory Government' set balanced development and decentralization as its key goals. This raised regional development as a national task, and Universities were identified as important vehicles for accomplishing this task. In this context, Ministry of Education and Human Resources Development in 2004 launched New University for Regional Innovation, or NURI Projects, which engages universities based in the provinces. 112 NURI project proposals were selected through highly competitive screening. In Busan alone 12 project teams have been chosen for financial support for 5 years under the NURI initiative.
The government initiative to strengthen the capacity for regional innovation has greatly emphasized the linkage between the education institutions and the industries.

Other public organizations

Busan Metropolitan City & Ulsan Metropolitan City
The 2 cities strongly support their ecosystem

Events:
BIMOS = Busan Internationa Motor Show

Innovation platforms

Busan TecnhoPark[82]

Established in December 1999 by the Ministry of Commerce, Industry and Energy to actively respond to today's changes and challenges, Busan Techno Park has been providing support for new technology development and corporate support services with organic cooperation among the industry, academies, research institutes and the government. Meanwhile it performs functions of a regional innovation organization including planning, R&D evaluation and post-management to nurture regional promotional industries and core strategic industries

Attached centres:

Mechanical Material and Parts Centre

Automotive Parts Technology Support Centre

[82] Source: Busan Technopark: http://eng.btp.or.kr

Centre for next generation Heat Exchangers

MEMS/NANO Fabrication Centre

Smart Electronic Support Technology Centre

Marine Bio-industry Development Centre

Centre for Logistics Management&Technology Support

Senior Products Industrial Centre

High-Technology Components and Materials Research Centre

Ulsan TechnoPark[83]:

The Ulsan Techno park (UTP), established in 2002 http://utp.or.kr/newenglish/ , is jointly owned by the Korean government and the Ulsan City Authority. Its goal is to situate resources such as universities, businesses and research institutes in one place, and become the centre for technological innovation, providing building facilities and equipment for research, testing and production.

Auto-parts Innovation Centre (APIC)[84]

- APIC, located in « Auto Valley » and created in 2006 http://www.apic.re.kr/motor_eng/index.jsp , is part of the Ulsan Techno park (UTP)
- APIC is an institute that supports the automotive parts industry, established jointly by the Ulsan city and the Ministry of Commerce, Industry and Energy.
- APIC is a network among automotive parts companies, vehicle assembly companies, universities, and related research institutes, to make all possible efforts to provide actual support through corporate / field centred management.
- APIC places a strong focus on Hybrid Electrical Vehicles (HEV) and Electrical Vehicles (EV), and is aiming at becoming the Korean competence centre in this field



[83] Source: Ulsan Techno Park: http://utp.or.kr/newenglish

[84] Source: Automotive Parts Innovation Centre www.apic.re.kr

The R&D centre has been established for technology innovation and product development of Ulsan's auto parts industry, boasting its highly-qualified researchers and state-of-the-art equipment.
Auto-part Innovation Centre is the general support institution which has been established by Ministry of Commerce, Industry and Energy and Ulsan Metropolitan City, and it's the central axis of Auto-valley, the core strategic industry. In addition, it masses auto-part manufacturers in Southeast area, and it performs business to keep the industrial competition through the cutting-edge technology development.

Field of business: Equipment sharing business / joint technology development business / enterprises support business / education and training business / networking business / new business nurturing business

Other interesting platforms:

- KTRI (Korea Testing & Research Institute) www.kotric.or.kr
- RIST (Research Institute of Industrial Science & Technology) www.rist.re.kr
- KITECH (Korean Institute of Industrial Technology) http://eng.kitech.re.kr

6.3.3. Cluster organization & management – Technological focus and organizational capability of the regional innovation system

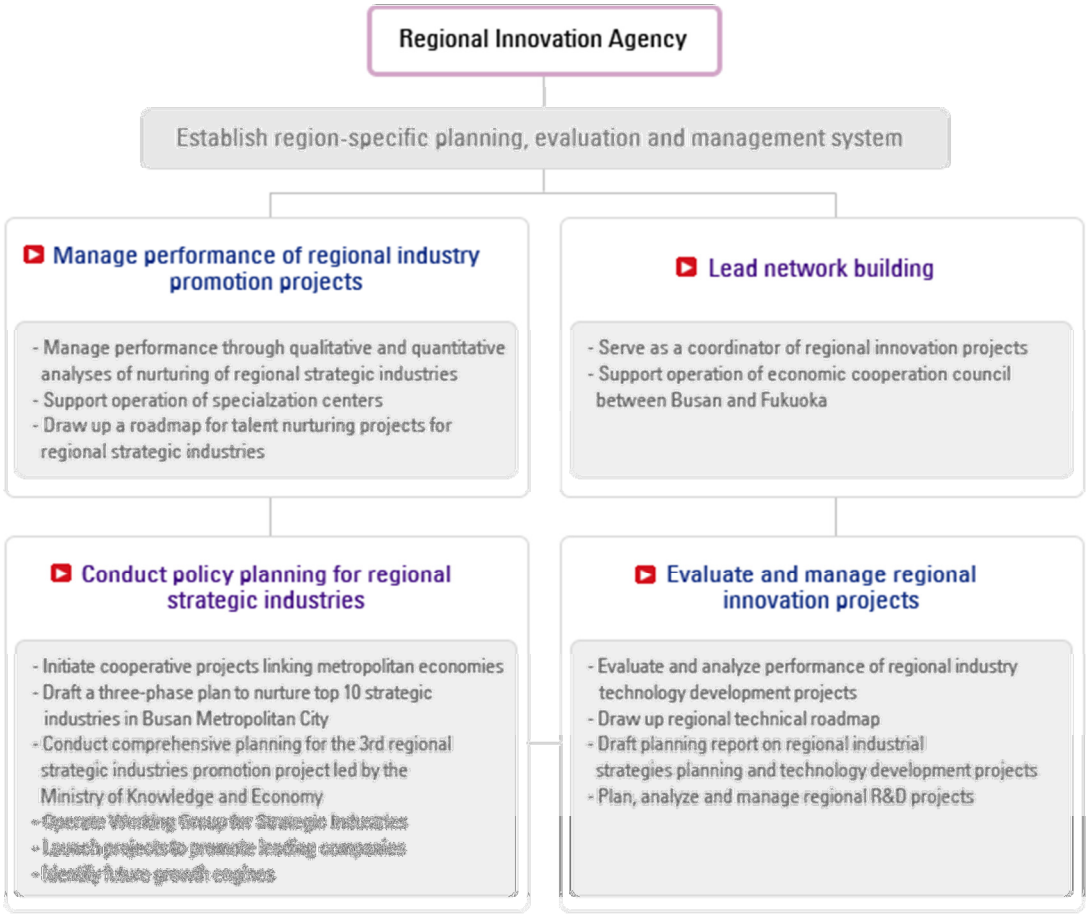


Figure 34: Regional innovation agency

6.3.4. Summary Busan/Ulsan

The Busan/Ulsan region is home of the Korean automotive Industry. The key industrial actors have their plants in this strategic location: the car-makers (Hyundai and Renault-Samsung-Motors) and the suppliers (Mobis, Posco and SK). Moreover, the region benefits an efficient educational system and a strong network of universities and public laboratories.

The clusters are supported by the national agency KICOX but also by Busan Metropolitan City and Ulsan Metropolitan City. They are mostly focused on production; the R&D activities being mainly located in the north of the country. The authoritarian model of Korean society, the competition between the 2 car makers and the supremacy of Hyundai do not encourage the development of “open” research driven clusters.

However we remark interesting practices through the 2 Techno parks (Busan Techno park and Ulsan Techno park). They provide support for new technology development and shared infrastructures. Owned by public authorities, they facilitate cooperation among the industry, academies, research institutes and the government. They are open to collaboration with European partners.

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7. SWOT

7.1. INTRODUCTION

SWOT analysis is a strategic planning method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats relevant to the project or business being analysed. In the case of SAGE International work package, the SWOT analyses relates to the study of nine selected automotive regions in Asia and their development potential in the field of safe and green road vehicles.

In a SWOT analysis it is common to divide the factors in internal and external.
Internal factors:

- Strengths: any existing or potential resources or characteristics of the cluster / stakeholders that give it an advantage over others
- Weaknesses are characteristics that place the cluster / stakeholders at a disadvantage relative to others

External factors:

- Opportunities: any existing or potential force in the external environment that, if properly leveraged, could provide a competitive advantage.
- Threats: external elements in the environment that could impede the development of the clusters and its stakeholders.

7.2. AIM OF SWOT ANALYSIS

The overall aim of the SWOT analysis within WP7 is to identify possible strengths and opportunities as well as weaknesses and threats for the nine selected regions in Asia. This information will later be the basis for decision when choosing which regions to continue to analyse and seek cooperation with within the SAGE project.
The SWOT results will be presented in this section but also form a basis for the continuing work during the next step of the international work package e.g. forming the International Collaboration Strategy.

7.3. METHODOLOGY FOR IDENTIFYING THE SWOTS OF A CLUSTER

Within SAGE WP 3- SWOT analysis, a methodology for measuring strengths, weaknesses, opportunities and threats has been developed. See Table 9

Dimensions	Factor
Economy	Presence / involvement of large Firms Enterprise Entrepreneurialism Supportive policy environment Access to Finance
Innovation	Innovative Technologies Physical Infrastructure Human Capital Supportive policy environment Access to Finance

Research and development	Physical Infrastructure Human Capital Supportive policy environment Access to Finance
Education	Physical Infrastructure Human Capital Supportive policy environment
Policy / cluster environment	Supportive policy environment Access to Finance Networking Partnership
Cluster organization	Supportive policy environment Access to Finance Networking Partnership

Table 9: Methodology for measuring strenghts, weaknesses, opportunities and threaths

The SWOT presented in this section is carried out by different representatives from the SAGE partnership organizations with local connection to the regions. The SWOT analysis is based on the characterizations of regions provided in earlier chapters in this report. The characterizations of regions are carried out both through desk-top research from a distance and by interactions with representatives from governmental agencies, private industries and independent organizations at site.

7.4. SWOT ANALYSIS OF MAPPED REGIONS

7.4.1. Beijing

Dimensions	Strengths	Weaknesses
Economy	• Beijing Municipal Government well planned and organized to build infrastructure for NEV and spread NEV both for public and private transportation; • Foton as the biggest auto company in Beijing , is involved both in R&D and manufacturing in the field of NEV from very beginning; • Having enough financial sources both from public and private investors	• Lack of big private firm like BYD whose strategy is to develop the new energy storage system and new energy vehicles.
Innovation	• Leading in NEV demonstration program for public transportation (particularly e-bus and e-sanitation trucks); • Good environment and supportive policy both for existent firms and start-up company involved in R&D	• Lack of good environment to enforce Intellectual property law well; • Safety of NEV technology still need to be improved

	and business in the area of NEV; • Good infrastructure for testing and certification of important components and systems for NEV;	
Research and development	• Well developed technology for key components (Motor and its controller, cells and battery system, technology platform, transmission) for NEV and enough local source to produce and provide these key components; • Enough funds and rapid development of infrastructure for NEV; • Own their own technology and patents for E-bus technology platform, charging/swapping infrastructure, motor and its controller and battery; • Rich national research bodies In Beijing; • Rich human capital in NEV technology	• Lack of international experience for their own technology • Lack of global standards and norm • Lack of good technology and serial production experience with hybrid drives
Education	• Qinghua University and other high quality universities of technology are located in Beijing and they attract the best students in China ; • Plenty of funding resources for updating the modern equipment for the research and education	• Lack of systematic training program for engineers in the field of E&HEVs • Education is too expensive for poor people; • Education program is not well correlated with actual society needs • in general, Chinese education system pays too much attention to the result of exams, other than cultivate students real ability
Policy / cluster environment	• The supportive policy and project funds from government guide the strong cooperation and networking partnership between universities, research institutions and industry;	• it might exist the corruption among the networking partnership

Cluster organization	• Established efficient working team (government officials and technical experts) to ensure the supportive policy and developing plan to be carried out in the right way and right direction	• Lack of clear cluster organization
Dimensions	**Opportunities**	**Threatens**
Economy	• China determined to be leader for NEV; • Potential biggest market for NEV; • Reduction of import dependence on petroleum; • securing energy source	• Safety of NEV • Unrealistic public expectations causing possible disappointment
Innovation	• Contribution to climate protection and reduction of local emissions; • Innovatory impetus for auto manufacturers and parts suppliers	• Lack of policy to avoid monopoly or unfair competition • The global economic crisis might decrease market demands for new technologies
Research and development	• Investors are looking for new business in the area of NEV; • Increased fuel prices has given boost for NEV	• Lack of international experience ; • In order to protect regional profits, local regional policy might prevent advanced technology from being widely applied
Education	• Beijing as the capital of China are attracting students from all over the world;	• The best Chinese talents are attracted by the top universities in the world;
Policy / cluster environment	• Contribution to climate protection and reduction of local emissions	• Isolated technical applications could impede market penetration
Cluster organization	• Potential worldwide cooperation	• understanding problem because of different needs and profits driven

Table 10: SWOT Beijing

Summary of SWOT Beijing

Strengths	Weaknesses

– Beijing Municipal Government well planned and organized to build infrastructure for NEV and spread NEV both for public and private transportation	– Lack of international experience for their own technology
– Leading in NEV demonstration program for public transportation (particularly e-bus and e-sanitation trucks)	– Safety of NEV technology still need to be improved
– Well developed technology of key components (Motor and its controller, cells and battery system, technology platform, transmission) for NEV and enough local source to produce and provide these key components	– Lack of global standards and norms
– Enough funds and rapid development of infrastructure for NEV	– Lack of good technology and serial production experience with hybrid drivelines
– Good environment and supportive policy both for existent firms and start-up company involved in R&D and business in the area of NEV	– Lack of good environment to enforce Intellectual property law well
– Good infrastructure for testing and certification of important components and systems for NEV	
– The supportive policy and project funds from government guide the strong cooperation and networking partnership between universities, research institutions and industry.	
– Established efficient working team (government officials and technical experts) to ensure the supportive policy and developing plan to be carried out in the right way and right direction	
– Rich education resources (both in University and National research bodies) In Beijing and rich human capital in NEV technology	
– Own their own technology and patents for E-bus technology platform, charging/swapping infrastructure, motor and its controller and battery	

Opportunities	Threats
– China determined to be leader for NEV – Potential biggest market for NEV	– Safety of NEV
– Reduction of import dependence on petroleum; securing energy source	– Unrealistic public expectations causing possible disappointment
– Contribution to climate protection and reduction of local emissions	– Lack of policy to avoid monopoly or unfair competition
– Investors are looking for new business in the area of NEV	– In order to protect regional profits, local regional policy might prevent advanced technology from being widely applied
– Innovatory impetus for auto manufacturers and parts suppliers	
– Increased fuel prices has given boost for NEV	

Table 11: Summary SWOT Beijing

7.4.2. Shanghai

Dimension	Factor (examples)
Economy	Strengths: • The best industrial region in China; there is the most diverse & largest scale of P&C base. • Shanghai is acknowledged in the automotive and academic circle for having the best investment environment, also an ideal location for manufacturing set up for the automobile industry. • New energy bus of 2010 was 598 units, which is 12.2% of all over China, Shanghai is key • Total industrial output for 2009 of Shanghai was 257 bil Yuan, which was 9.68% of China's total industrial output; Sales value 253 bil Yuan, which was 9.53% of total; automobile volume 1250 thousand units, increased by 55% than that of the last year. • Total 53 enterprises of SAIC were awarded with hi-tech Weaknesses: • Severe competition • Economy of China other cities is growing, thus sharing market • Shanghai can't always keep the no.1 in China
Innovation	Strengths: • 2825 patents were applied during 2006-2010, which was increased by 5.3 times than 2001-2005 • 2018 patents were authorized, 4.4 times equally

	• Shanghai NEV was awarded with Science & Technology Advancing of China Auto Industry 33 times and by Shanghai Municipality 23 times • There will be an electronic rail for city bus line in District Minhang in the end of 2012 Weaknesses: • Low scale of lithium battery manufacturer; • Don't own key technology of lithium battery, thus hard to support NEV industry • Low production and weak technology for motor; Limited channel of funds, too much dependence on import, no localization. • Lack of technology for controlling system locally Opportunity: • Actively incubate the development of local lithium battery, lessen the dependence on outer battery suppliers, and owns the technology. • Delphi, Continental, Bosch. AVL, FEV, Ricardo involved in R&D of controlling system, is improving the technology Threats: • Overseas motor manufacturers (Bosch, Continental, SKF, Hitachi, Fuji, and Mitsubishi) always impact local products
R&D	Strengths: • Shanghai is in the advantageous position with technical competence and financial power. • Power, charging facilities are in lead level in China. E.g. there have been 6 charging stations, 100 charging posts. • World Expo 2010 has promoted much building for service facilities, e.g. Charging speed: 10min/bus, with battery changing robot. • There is a new rubber tire tram operated in hi-tech park for demonstration which won good reputation. • Aiming to hybrid, electric vehicle, developing the technology of battery, motor, controlling system, Shanghai will build NEV industry network and cluster. Weaknesses: • Battery issues (high cost, much variant, and no standards) need to be solved • It is hard to build charging stations and posts in so large congest down town, what will cause limited market and limited acceptance from customer on NEV. Opportunities: • Shanghai will build up 5000 charging stations before end of 2013 • Motor and controlling system can be industrialized. • Shanghai will build electronic rail bus which comes up with advanced technology Threats:

	• Demand of charging increased dramatically
Education	• Strong universities like Tongji with a lot of international collaborations.
Policy/cluster environment	Strengths: • Government subsidy, favourable tax revenue and incentive actively support to transportation & service fleet even private for NEV demonstration and popularization • Shanghai is the first international demonstration city for NEV in China • Not only support R&D, but also support NEV's industrialization • Detail supporting policy: Political Provisions on Promoting the Development of SH New Energy Automotive Industry Weaknesses: • Perfect policy but lack of supporting strength; • Most of purchasing is allocated by government, common consumers are watching. Opportunities: • Tougher and tougher emission regulation requires more application of NEV • Attitude of consumers is being transferred from watching to purchasing along with developed policy and facilities. • P&C technology will be much advanced in the near future
Cluster organization	Opportunities: • 10 governmental Departments involved in NEV • SAIC has been listed as trial enterprise for NEV • SAIC is the largest automotive group in China, owns diverse business. SAIC has set up short/long term objectives for developing NEV. SAIC has integrated the source of Tongji University, Jiaotong University, Finance and products • SAIC has supplied 1300NEVs for World Expo. • Other OEM out of SAIC such as Huapu, Daewoo, Sunlong produce all kind of NEVs Weaknesses: • Competitiveness is relative moderate on market and price, but severe on R&D and promotion. Threats: • Cooperation and alliance with local enterprises; but competition with international enterprises.

Table 12: SWOT Shanghai

Summary of SWOT Shanghai

Strengths	Weaknesses
– Shanghai is acknowledged in the	– Good policy regarding NEV

automotive and academic circle for having the best investment environment, also an ideal location for manufacturing set up for the automobile industry.	industrialization but lack of supporting strength. Most of purchasing is allocated by government, common consumers are watching.
– New energy bus of 2010 was 598 units, which is 12.2% of all over China, Shanghai is key demand region	– Battery issues (high cost, much variant, and no standards) need to be solved
– 2825 patents were applied during 2006-2010 whereof 2018 patents were authorized.	– It is hard to build charging stations and posts in so large congest down town, what will cause limited market and limited acceptance from customer on NEV.
– Power, charging facilities are in lead level in China. E.g. there have been 6 charging stations, 100 charging posts.	
– NEV engineering centre in Tongji university was set up with investment in 2002, and it is the key base of NEV training and innovation for China.	
Opportunities	**Threats**
– SAIC has been listed as trial enterprise for NEV	– Severe competition - economy of other cities in China is growing, thus sharing market.
– Since Shanghai is aiming to develop hybrid, electric vehicle by developing the technology of battery, motor, controlling system. Shanghai will build NEV industry network and clusters.	– Cooperation and alliance with local enterprises; but competition with international enterprises. Overseas motor manufacturers (Bosch, Continental, SKF, Hitachi, Fuji, and Mitsubishi) always impact local products.
– Actively incubate the development of local lithium battery, lessen the dependence on outer battery suppliers, and owns the technology.	– Demand of charging increased dramatically
– Shanghai plan to build up 5000 charging stations before end of 2013	
– Motor and controlling system can be industrialized.	
– Shanghai will build electronic rail bus which comes up with advanced	

technology.	
– Tougher and tougher emission regulation requires more application of NEV.	
– Shanghai is in the advantageous position with technical competence and financial power.	

Table 13: Summary SWOT Shanghai

7.4.3. Xi'an

Dimension	Factor (examples)
Economy	• Ranked 28 among major Chinese cities in GDP in 2011. The GDP value is 324.15 billion YMB • The most developed city and the connecting gateway to western China • The city government has the equal right as the provincial government in the economic policy • The city is active in attracting foreign investment and establishing international R&D collaboration • Three top-level Chinese automotive OEMs have design and manufacturing facilities in Xi'an • Samsung will start an enormous production centre in Xi'an and the centre is the largest foreign investment in electronics and IT technology since the establishment of new China • The automotive industry has shown a rapid growth during the last decade. This symbolizes the dedicated support to the automotive sector from the city and provincial governments • Special benefits are granted to the enterprises in several special development zones. One of the zones is dedicated to the automobile industry • Foreign investments are encouraged and enjoy special benefits on facility usage, tax, and fundraising
Innovation	• Xi'an is a centre of aeronautics and aerospace technology • A few institutes and universities are taking critical roles in the Chinese manned space program • A large number of research universities • The universities and institutes receive ample funding from the government and the industry • There is a number of research centres and key laboratories dedicated to the automotive engineering • The universities and the automotive industry have healthy collaboration • There are several industrial parks and service centres to give policy and financial support to start-up companies
R&D	• Chang'an University is a public university specialized in transportation and vehicle engineering. It is ranked number 1 among all Chinese universities in the field of transport engineering • Xi'an Jiaotong University is the best comprehensive university in Xi'an. It has a research centre on full electrical vehicles

	• Shaanxi Automobile Group focuses on the design, development, manufacturing and service of commercial vehicles. It is the largest OEMs and the unique corporation on new energy commercial vehicles in North-Western China • Suda is an emerging corporation supported by the government to develop and manufacture full-electrical vehicles • Shaanxi Fast Auto Drive Group is the largest supplier in China for heavy-duty auto transmission, auto gears • There is a special economic zone in Xi'an for the automobile industry
Education	• Xi'an Jiaotong University • Chang'an University • North western Polytechnical University • Xidian University • Xi'an University of Technology • The universities receive a large amount of teaching and researching funding from the government and the industry • Universities are eager to have industrial collaboration • There is special funding to support the technology transfer
Policy/cluster environment	• High-tech and innovative corporations are concentrated in several special development zones • Innovative companies enjoy various kinds of benefits in these zones • Xi'an Municipal Development & Reform Commission makes grand policy framework and economic development plan • Xi'an Science Technology Bureau enforces and supports national, provincial and municipal policies on science and technologies • Xi'an Municipal Industry & Information Commission enforces and supports the policies and laws on industrialization and information technology, supervise the innovation and technology advancement in industry • Xi'an Association for International Exchange of Personnel attracts and helps foreign experts to work and live in Xi'an
Cluster organization	• Universities, research institutes, and high-tech companies maintain tight collaboration on R&D projects and fund raising • The primary government service is Xi'an Pioneering Park Development Centre, which is responsible for supporting start-up business, incubating emerging technologies, fundraising for R&D projects, etc.

Table 14: SWOT Xi'an

Summary of SWOT Xi'an

Strengths	Weaknesses
– Xi'an area is traditionally strong in aeronautics and aerospace related technology	– The economic development is still far behind Beijing and Shanghai
– The automotive industry has made significant improvement recently	– The level of overseas investment and international collaboration is still lower than Beijing and Shanghai

– Two automotive corporations are ranked within 20 among all Chinese automotive enterprises	– The consumers capability and the market activity are lower than Beijing and Shanghai
– Xi'an is geographically the centre of China and serves as an critical gateway connecting East and West China	
– Xi'an has a large number of universities and research institutes. The human resource is ample and relatively cheap	
– Cost of human resource, energy, facility, and other business overhead is lower in Xi'an than other developed area	
– The infrastructure on road transportation is advanced	
Opportunities	**Threats**
– Xi'an is approved by the national authority to start the program of building a low carbon transportation system	– The unbalanced economic development in China may be aggravated
– The economic development in China is unbalanced between the east and the west. A strategic economic policy is to boost the economic increase of West area	– Intellectual property may not be well protected
– On June 25th, 2009, the national authority announced the Development Plan for Guangzhong-Tiansui Economic Zone. Xi'an is the core of this economic zone and will be upgraded into an International Metropolitan with the same roles of Beijing and Shanghai	– More emphasis may be put on manufacturing or product development rather than innovative research
– Xi'an is the critical city to transport natural resources, like coal, oil, gas, and mine, from Western China to Easter China	

Table 15: Summary SWOT Xi'an

7.4.4. Tokyo

Dimension	Factor
Economy	• Tokyo economy is based on the industrial and services sector. Tokyo

	worldwide is renowned as a city of automobile, electronic, chemical and heavy industries. It is the political and commercial capital of Japan, perhaps the most technologically developed nation of the world • Tokyo is the decision centre of the country and home of the major companies' headquarters (famous "keiretsu") • Presence of large automotive firms: Nissan Motor, Hino Motors, Isuzu, Mitsubishi Motors, Honda, Subaru (Fuji Heavy Industries), UD Trucks, Denso
Innovation & R&D	• The region is well known for its capacity of innovation in electronics and IT. • Network of innovative SMEs in the region • Japanese culture, rigidity of the structures, hierarchy and vertical organization doesn't enable Open Innovation
Education	• Tokyo has many universities, junior colleges, and vocational schools. Many of Japan's most prestigious universities are in Tokyo, including University of Tokyo, Hitotsubashi University, Tokyo Institute of Technology, Waseda University, and Keio University
Policy/cluster environment	• National cluster policy leads by METI for "Industrial Cluster" and by MEXT for "Knowledge Cluster" • No local cluster policy identified • New policy changes that encouraged professors to commercialize innovations
Cluster organization	• No automotive cluster organization in Tokyo • The collaboration between Japanese car manufacturers happens in JARI on specific themes (electric, hybrid, fuel cell). Some universities are working on automotive topics but the main part of R&D is done internally by each manufacturer

Table 16: SWOT Tokyo

Summary of SWOT Tokyo

Strengths	Weaknesses
– Important academic skills	– Strong dependency to Nissan
– Japan is the leader country in automotive industry with a strong focus on Safe and Green mobility	– The vertical organization doesn't facilitate large interactions
– Headquarters of major companies are located in Tokyo	– No real industrial concentration in the automotive sector
Opportunities	**Threats**

– Centre of political decision: place-making of cluster public policy	– Major industrial stakeholders are not really open to cooperation
– Cooperation are discussed within the JARI	– Long time needed to build a relation of confidence
– Significant Skills in ICT, Mechatronics, ITS etc.	– Competition from South Korea, China and India

Table 17: Summary SWOT Tokyo

7.4.5. Nagoya

Dimension	Factor (examples)
Economy	– Greater Nagoya has a very strong economic ability with more than 1 % of world GDP – Presence of large automotive firms; Toyota, Mitsubishi and DENSO for example.
Innovation	– Major industrial stakeholders have strong in-house research facilities
R&D	– Research focus has been on material and manufacturing traditionally.
Education	– There are 22 universities in the area
Policy/cluster environment	
Cluster organization	– The cluster has shown a proactive trend in the area of alternate fuels especially in the area of hybrids and plug in hybrids

Table 18: SWOT Nagoya

Summary of SWOT Nagoya

Strengths	Weaknesses
– Presence of strong automotive players (global as well as local) Toyota, Mitsubishi, DENSO etc.	– Major industrial stake holders conduct their research in-house, to a large extent
– Strong in house research facilities	– Mostly Japanese global companies in the clusters. Cross cultural interaction would help to bring more interaction into the system
– Very good financial support from government as well as industry	

– Innovative concept has been developed in region on green vehicles (electric)	
– Research focus on material, manufacturing, environment can help for future development	
– Economic ability – greater Nagoya more than 1 % of world GDP	
Opportunities	**Threats**
– Cluster can play pivotal role in Asia to guide other clusters to grow	– Dominated by only few players which had legacy in this region
– Global collaboration would bring better knowledge transfer	– Knowledge transfer could be the challenge
	– Lack of inter cluster interaction

Table 19: Summary SWOT Nagoya

7.4.6. Mumbai/Pune

Dimension	Factor (examples)
Economy	• Mumbai is India's largest city (by population) and is the financial and commercial capital of the country as it generates 6.16% of the total GDP. It serves as an economic hub of India, contributing 10% of factory employment, 25% of industrial output, 33% of income tax collections, 60% of customs duty collections, 20% of central excise tax collections, 40% of India's foreign trade and ₹4,000 crore (US$798 million) in corporate taxes. • Maharashtra is the richest state in India, contributing 15% of the country's industrial output and 13.3% of its GDP (2006–2007 figures). Maharashtra has made great studies in the industrial sphere with Bombay city as the centre. • Maharashtra's gross state domestic product for 2011 is estimated at ₹901,330 crore* (US$179.82 billion).Maharashtra's GDP Per Capita crossed the US$ 2,000 threshold for the first time in 2011 making it one of the richest states in India. • Pharmaceuticals, petrochemicals, heavy chemicals, electronics, automobiles, engineering, food processing, and plastics are some of the major industries of the state. • Maharashtra is renowned for the production of three-wheelers, jeeps, commercial vehicles and cars, synthetic fibres, cold rolled products and industrial alcohol. Small scale industries have also come up in a big way in the state. • Maharashtra has set up software parks in Pune, Mumbai, Navi Mumbai, Nagpur and Nasik, Aurangabad. Now Maharashtra is the second largest

	exporter of software with annual exports of ₹18 000 crore and accounts for more than 30 per cent of the country's software exports, with over 1,200 software units based in the state. • Automotive Industry: o The western hub is 33% of the automotive market. o The Chakan corridor near Pune is the western cluster with companies like General Motors, Volkswagen, Skoda, Mahindra and Mahindra, Tata Motors, Mercedes Benz, Land Rover, Fiat and Force Motors having assembly plants in the area. o Aurangabad with Audi, Skoda and Volkswagen also forms part of the western cluster. o Another emerging cluster is in the state of Gujarat with manufacturing facility of General Motors in Halol and further planned for Tata Nano at Sanand. Ford, Maruti Suzuki and Peugeot-Citroen plants are also set to come up in Gujarat.
Innovation	• Maharashtra has good human resource development infrastructure in terms of educational institutions—301 engineering/diploma colleges, 616 industrial training institutes and more than 24 universities with a turnout of 160,000 technocrats every year. • It is home to some of the country's best institutions. The following are the main educational institutes in the region: o Engineering & Sciences: Indian Institute of Technology (IIT-B), Mumbai, Visvesvaraya National Institute of Technology (VNIT), Veermata Jijabai Technological Institute (VJTI), Sardar Patel College of Engineering, University Department of Chemical Technology, College of Engineering Pune (COEP), Fergusson College, Pune, Government College of Engineering Aurangabad, Government College of Engineering Amravati, Government College of Engineering Karad, Walchand College of Engineering, Sangli (WCES), Shri Guru Gobind Singhji Institute of Engineering and Technology Nanded (SGGSIE&T). o Research & Development: Tata Institute of Fundamental Research (TIFR) and the Bhabha Atomic Research Centre (BARC), Automotive Research Association of India (ARAI), AutoCluster Development &Research Institute Ltd., National Chemical Laboratory (NCL: One of the leading chemical research establishments in India), Indian Institute of Science Education and Research, Pune (IISER, Pune), Inter-university Centre for Astronomy & Astrophysics (IUCCA), National Centre for Radio Astrophysics (NCRA), Centre for Development of Advanced Computing (C-DAC), Electronics Test and Development Centre (ETDC : Under the STQC directorate, it is a leading testing and certification centre) , National Institute of Virology (NIV), Indian Institute of Tropical Meteorology (IITM): Scientists at IITM has several significant achievements in tropical weather, National Informatics Centre (NIC), Armament Research Development Establishment (ARDE), High Energy Materials Research Laboratory (HEMRL), Bhandarkar Oriental Research Institute (BORI), Agharkar Research Institute (ARI), National Environmental Engineering Research Institute (NEERI)
R&D	• The Western Cluster is comparatively new for Automotive as compared to the Eastern Cluster (Bangalore – Chennai Region). As a result the working models and government organizations present in the Bangalore-Chennai region are

	more mature. • However, the western cluster is the new and upcoming region. The boundary of this cluster is slowly expanding to also include the state of Gujarat (region of Sanand-Mehsana) . It is expected that by 2015-16, nearly one of every three cars that roll out in the country could be from Gujarat. Estimates show that in the next three-five years, half the installed capacity for making cars in India will be located in the state. Many carmakers have already shifted their focus to the region e.g. Maruti Suzuki, Peugeot PSA, Ford India and Kia Motors, Tatas and General Motors. • The Key advantages of the Western Cluster: o Trade & Commerce Hub of India: Mumbai in Maharashtra is known as the trade and commerce capital of India. The city is also the financial centre of the country. In recent years, Maharashtra has emerged as a key hub for IT and ITeS, electronics, and the captive business outsourcing industries. o Policy and fiscal incentives: Maharashtra offers a wide range of subsidies, fiscal and policy incentives and assistance for businesses under the "Industrial, Investment and Infrastructure Policy, 2006". The state also has sector-specific policies for IT and ITeS, biotechnology and automotive. o Abundant labor pool: Maharashtra has a literacy rate of 76.9 per cent. The state has a large base of skilled and industrial labor, making it an ideal destination for knowledge-based and manufacturing sectors. o Facilitating infrastructure: The state has a well-developed social, physical and industrial infrastructure. It has good road, rail, port and air connectivity. Apart from eight airports, the state has two major and 53 minor ports. It also has a well-developed power supply grid. o High infrastructural growth: Maharashtra has had high growth in the infrastructure sector in the last decade. Recently, there has been a considerable increase in the number of industrial clusters, and public private partnerships projects in the in the infrastructure domain. o Stable political environment: The state has a stable political environment with a single party government. The State Governments is committed towards providing conducive business climate through progressive policies and incentives. • Main players in the region are: o Tata Motors: Full Corporate footprint in Western Hub including most manufacturing plants. o Mahindra & Mahindra: Most of Corporate footprint in Western Hub including most manufacturing plants. o Fiat India Automobiles Private Limited o VW Group: Full corporate footprint in Western Hub . o Bajaj Auto: Full Corporate footprint in Western Hub. o Mercedes: Assembly plant and small research in Pune. o Force Motors: JV with MAN for heavy commercial vehicles. o Kirloskar Oil Engines: Major Hub for development and manufacturing. o Cummins India: Full Corporate footprint in Western Hub. o General Motors: Assembly plant and some development. o Auto Cluster R&D Inst. Ltd. o Automotive Research Institute of India o Continental Automotive Components (India) Pvt Ltd
Education	• Maharashtra has good human resource development infrastructure in terms of educational institutions—301 engineering/diploma colleges, 616 industrial training institutes and more than 24 universities with a turnout of 160,000

	technocrats every year. • List of Universities: o Engineering & Sciences: Indian Institute of Technology (IIT-B), Mumbai, Visvesvaraya National Institute of Technology (VNIT), Veermata Jijabai Technological Institute (VJTI), Sardar Patel College of Engineering, University Department of Chemical Technology, College of Engineering Pune (COEP), Fergusson College, Pune, Government College of Engineering Aurangabad, Government College of Engineering Amravati, Government College of Engineering Karad, Walchand College of Engineering, Sangli (WCES), Shri Guru Gobind Singhji Institute of Engineering and Technology Nanded (SGGSIE&T). o Management: Narsee Monjee Institute of Management Studies (NMIMS), National Institute of Industrial Engineering (NITIE), Jamnalal Bajaj Institute of Management Studies (JBIMS), S P Jain Institute of Management and Research, K J Somaiya Institute of Management Studies and Research. o Arts & Law: Government Law College and Sydenham College, the oldest law and commerce colleges in India, are based in Mumbai. The Sir J. J. School of Art is Mumbai's oldest art institution. Film and Television Institute of India, National Film Archives, ILS Law College. o Medical: Armed Forces Medical College, Byramjee Jeejeebhoy Medical College, Military Nursing College. o Research & Development: Tata Institute of Fundamental Research (TIFR) and the Bhabha Atomic Research Centre (BARC), Automotive Research Association of India (ARAI), Auto Cluster Development &Research Institute Ltd., National Chemical Laboratory (NCL: One of the leading chemical research establishments in India), Indian Institute of Science Education and Research, Pune (IISER, Pune), Inter-university Centre for Astronomy & Astrophysics (IUCCA), National Centre for Radio Astrophysics (NCRA), Centre for Development of Advanced Computing (C-DAC), Electronics Test and Development Centre (ETDC : Under the STQC directorate, it is a leading testing and certification centre) , National Institute of Virology (NIV), Indian Institute of Tropical Meteorology (IITM): Scientists at IITM has several significant achievements in tropical weather, National Informatics Centre (NIC), Armament Research Development Establishment (ARDE), High Energy Materials Research Laboratory (HEMRL), Bhandarkar Oriental Research Institute (BORI), Agharkar Research Institute (ARI), National Environmental Engineering Research Institute (NEERI)
Policy/cluster environment	• The main policies of the region originate in the corporate sector. The direction of the various organizations then gets mapped as the research in the various academia and R&D institutes in the region. There is very little policy making, influencing directly the automotive industry that originates directly from the state or the central government. • Industrial, Investment and Infrastructure Policy: The policy aims to achieve higher and sustainable economic growth with emphasis on balanced regional development and employment generation through greater private and public investment in industrial and infrastructure development. o Institutional framework for policy implementation. o Identification of thrust sectors. o Building up of quality infrastructure. o Incentivizing investments for employment generation in districts low on

	human development index (HDI). o Attracting mega investments, both foreign and domestic. o Commercial exploitation of local resources and local economic potential. o Strengthening the small and medium enterprises (SME) sector through promotion of quality competitiveness, research and development and technology up-gradation. o Nurturing industrial clusters. o Prevention of industrial sickness and revival of viable sick units. o Smooth exit option for industries. o Streamlining procedures, debottlenecking and creation of hassle-free, industry-friendly environment. o Strengthening institutional support. • IT & ITES Policy: The policy aims make Maharashtra the most favored destination for investments in the IT and ITES industry. o Institutional framework for policy implementation. o Unique information infrastructure. o Developing a pool of skilled, globally employable manpower. o Industry friendly and supportive environment. o Fiscal incentives. o Support to IT and ITeSunits by urban local bodies. o Rewarding outstanding performance of IT and ITeSunits. • Maharashtra Biotechnology Policy: To develop the biotechnology industry in the state and to lead the industry to a growth path so that it can become globally competitive.
Cluster organisation	• Tata Institute of Fundamental Research (TIFR): The Tata Institute of Fundamental Research is a National Centre of the Government of India, under the umbrella of the Department of Atomic Energy, as well as a deemed University awarding degrees for master's and doctoral programs. At TIFR, basic research in physics, chemistry, biology, mathematics, computer science and science education is carried out. The main campus is located in Mumbai, with additional campuses in Pune, Bangalore and Hyderabad. • The Bhabha Atomic Research Centre (BARC): It is India's premier nuclear research facility based in Mumbai. BARC is a multi-disciplinary research centre, covering the entire spectrum of nuclear science, engineering and related areas. o BARC's core mandate is of nuclear energy, primarily for power generation. It manages all facets of nuclear power generation, from theoretical design of reactors, computerized modelling and simulation, risk analysis, development and testing of new reactor fuel materials, etc. It also conducts research in spent fuel processing, and safe disposal of nuclear waste. Its other research focus areas are applications for isotopes in industries, medicine, agriculture, etc. o It also conducts research in Liquid Metal Magnetohydrodynamics for power generation. • Automotive Research Association of India (ARAI): o Collaborations with Indian Universities to provide Masters Courses. o Formulation of Policies and standards (helps the government, in doing so) o R&D Services, Consulting, o Design & Dev., Testing & Validation o Automotive Electronics (in-vehicle n/w & comm.) o NVH Refinement of Vehicles and Subsystems & CAE Engine o Vehicle Dynamics, Structures and Material.

	○ Hybrid Vehicles, ITS, EV etc. – imp for national consideration. ○ Governing Committee of Auto cluster, technical consultants to them. • Auto Cluster: ○ Established under the Industrial Infrastructure Up gradation Scheme (IIUS) of the Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India. ○ Design Centre : Support Research & Development ○ Tool Room ○ Rapid Prototyping Centre ○ Rubber Polymer Lab ○ Environment Test Chambers ○ Testing & validation of automotive plastic rubber, electronic component. ○ Business Development Centre

Table 20: SWOT Mumbai/Pune

Summary of SWOT Mumbai/Pune

Strengths	Weaknesses
– Strong policy making: The policy aims to achieve higher and sustainable economic growth with emphasis on balanced regional development and employment generation through greater private and public investment in industrial and infrastructure development	– Automotive main focus on manufacturing, R&D is under represented
– Cluster organization: The cluster is mainly organized through Automotive Research Association of India (ARAI) and Auto Cluster	– Lack of strong Govt. Policies/Regulations.
– Competences: All main competences are available in the cluster. Many Automotive players are present in the cluster.	– Lack of skilled and trained workforce.
– Size: The size of the West Indian Hub is comparable to the European regions. However in terms of Safe and Green Road Transport it is smaller due to less Automotive R&D activities	– Intervention of Politics.
– The West Indian Hub has a large number of universities and research institutes. The human resource is ample and relatively cheap	– Low productivity.
– The economic development is very strong	– Low level of mechanization & poor infrastructure facility.

	– Lack of transparency, trust and responsibility.
	– Slow absorption of innovation/change.
Opportunities	**Threats**
– The opportunity is to collaborate with an existing Cluster Organization, which includes many major stakeholders from automotive and non-automotive sectors being available, supported by a good infrastructure and education	– No Concrete roadmap for safe and green road transport.
– Increase of the Automotive R&D in the cluster with a strong focus to safety and energy saving would be favourable	– High Corruption levels,
– This could give us a freedom to set up new projects for Safe and Green Automotive Road Transport	– The rising inflation, hording and black-marketing take focus away from development of transport.
– Cooperation could be done via Automotive Research Association of India (ARAI) or Auto Cluster	– Self-cantered political leadership.
– Large number of tier 2 and rural areas which do not have appropriate road conditions.	– Slow & Dysfunctional judiciary and corrupt law enforcers
– Willingness of unionized employees and Academic Institutions (ARAI, IIT etc.)	

Table 21: Summary SWOT Mumbai/Pune

7.4.7. Bangalore/Chennai

Dimension	Factor (examples)
Economy	**Presence/involvement of large firms:** **Global OEMS**: Volvo, Ashok Leyland, Hyundai, Ford, Bharat Benz , Nissan, Renault cars. Domestic players: Ashok Leyland, TVS **Local suppliers**: Apollo tires, MRF, Rane group, Brakes India ltd. **Global tire** I: suppliers like Bosch, Delphi, Valeo., Continental **Supportive policy environment:** FDI 2000-2011 In state of Karnataka and Tamil nadu : 14.5 Billion $ Karnataka new Industrial Policy 2009-2014 New Infrastructure Policy 2007
Innovation	**Supportive policy environment:** Plan to start national automotive board, release of new energy vehicle policy

	and formation of National council for electric mobility **Access to finance:** Government promotes identifies the research in specific areas like alternate fuels, ICT based services though tax exemptions, research funding
R&D	**Physical infrastructure:** Hosts many public sector R&D units like ISRO, DRDO, BHEL, BMEL and research agencies **Supportive policy environment:** Tax exemption for recognized R&D Duty free import for hybrid vehicle related research **Access to finance:** Funding opportunities for research in specific area. Preference is given to academic and government research bodies.
Education	**Physical infrastructure:** Tamil Nadu: 65 universities,456 engineering collages, 366 poly technics Premier schools: Institute of Technology (IIT), Madras, Anna University National Institute of Technology (NIT) Karnataka :16 universities,166 engineering collages, 207 poly technics Premier schools: Indian Institute of Science, Indian Institute of Management HDI: 0.736(well above national average) **Human Capital:** Karnataka: Human development index HDI:0.66 with 66.7% literacy rate Tamil Nadu: Human Development index HDI :736 with 80.3% literacy rate
Policy/cluster environment	**Supportive policy environment (various state Govt. policies)** Karnataka New industrial policy 2009-2014 Karnataka SEZ policy 2009 New infrastructure Policy 2007 New special economic zone policy 2007 Tamil Nadu SEZ policy 2003 Tamil Nadu Industrial Policy 2007
Cluster organization	**Supportive policy environment:** Karnataka Industrial Area Development Board (KIADB), Tamilnadu Industrial Development corporation (TIDCO) helps to organize the cluster **Networking partnership** CII, FICCI nodal non-government ,ACMA, SIAM with local chapters in Chennai

Table 22: SWOT Bangalore/Chennai

Summary of SWOT Bangalore/Chennai

Strengths	Weaknesses
– Large domestic market	– Policies are driven by consumer demand and not by government
– Supply of skilled human resource	– Infrastructure development is slow
– Presence of global as well as local players	– Corruption

– Government initiative for new energy vehicles	– Research collaboration at academia and it's transfer to industry
– Large investment in setting up facilities in cluster	– Inter-industry collaboration for research for technology development
Opportunities	**Threats**
– Potential to grow as lead market for new energy vehicles	– Lack of inter cluster interaction
– Open to adaption to international technologies	– Intellectual property policy to be decided
– Increased fuel prices has given boost for new energy alternatives	–
– No established players in new energy vehicles	–

Table 23: Summary SWOT Bangalore/Chennai

7.4.8. Daejeon

Dimension	Factor (examples)
Economy	– Small country with dense population – minimized travel distances.
Innovation & R&D	– Close to and with easy access to Seoul – Satellite city to Seoul focusing on science and technology
Education	– Most of the highly educated people live in Seoul and Daejeon is close enough to commute to
Policy/cluster environment	– Public funding opportunities within applied ground transportation. Collaboration between academia and industry is focused. Public funding agencies are located within the Daedeok complex.
Cluster organization	– Presence of Science and Technology Complex gathering the industry, academia and the national labs in one place.

Table 24: SWOT Daejeon

Summary of SWOT Daejeon:

Strengths	Weaknesses

– Presence of Science and Technology Complex gathering the industry, academia and the national labs in one place.	– R&D centre to the actual plant gap existing.
– Efficient work-flow with highly educated experts in engineering and in schools**.**	– Slight language barrier for small and mid-sized enterprises
– Ease access to the capital where majority topics are focused.	
Opportunities	**Threats**
– Power, energy and materials are some of the most important topics in development.	– Preference over local companies and universities for public funding.
– Mature for the collaboration among the industry and academia. (Public Funding)	
– EV's in demand. Fuel price and the inefficiency of LPG.	

Table 25: Summary SWOT Daejeon

7.4.9. Busan/Ulsan

Dimension	Factor (examples)
Economy	• Korea's Southeast Economic Belt, where Korea's leading industries are located: shipbuilding, automotive, machinery • The Busan/Ulsan region is home of the Korean automotive industry. • The key industrial actors have they plants in this strategic location: the car-makers (Hyundai and Renault-Samsung-Motors) and the suppliers (Mobis, Posco and SK). • Presence of the main international automotive suppliers: Continental, Bosch, Denso, Faurecia, Valeo etc. • Clusters of SMEs that are in the growing phase
Innovation & R&D	• Busan-Ulsan clusters are industrial clusters. The activities focus mostly on production, rarely on R&D (the R&D activities are located in the north of the country) • Efficient collaboration between universities, research institutes and industry • R&D competencies and capital structure are weak. Companies are generally focused on low value-added tall processing activities • The will to establish a R&D cluster focused on Green Tech in order to create high degree of additional value
Education	• The region benefits an efficient educational system and a strong network of universities and public laboratories: Busan National University of Education, Pusan National University, Pukyong National University, University of Ulsan, Postech • Lack of research personnel and capabilities at corporate research

	institutes located in regional areas (R&D is in Seoul and Daejeon)
Policy/cluster environment	• The region is the hub of industrial clusters in Korea • The cluster policy is driven by the Ministry of Knowledge Economy with its agency Korea Industrial Complex Corp. (KICOX) • Busan Metropolitan City and Ulsan Metropolitan City strongly support the clusters located in their area.
Cluster organization	• Shared infrastructures and support services : Busan Techno park, Ulsan Techno park • Mini-Cluster (MC): This is a consultative body that consists of industry, academia, research, and government officials and is related to a specific industry type or technology area: Base industry (root industry), Automotive parts manufacturing, Green materials and parts, Shipbuilding and marine equipment, Plants, New & renewable energy.

Table 26: SWOT Busan/Ulsan

Summary of SWOT Busan/Ulsan

Strengths	Weaknesses
– Strategic location with advanced facilities, infrastructures and logistics	– No cooperation amongst the 2 main car makers: Hyundai and RSM
– Triple helix well represented: o Presence of the main OEMs (Hyundai and RSM) and their suppliers o An efficient educational system and a strong link between universities (public laboratories) and industry o Strong public supports at national and local level (tax credit, R&D funding, public research…) and a lot of incentives to boost innovation and cooperation	– Cluster system not really efficient due to the vertical integration of R&D: OEMs / Supplier relations and not partnership relations
– Major stakeholders invest a lot on R&D	– No autonomy of the clusters: strong dependency from government and industry
– Fastness to implement innovations to the market	– Lack of innovation and creative spirit (the Koran model is based on technical recovery and copy)
– Busan Techno park and Ulsan Techno park	– Most companies in the Cluster are not

provide support for new technology development and corporate support services with organic cooperation among the industry, academies, research institutes and the government	interested in R&D activities and focused mostly on production
Opportunities	**Threats**
– Possibilities of cooperation with RSM (Renault Samsung Motors) and its ecosystem in Busan	– Chinese competition
– Industrial cluster but wants to become an Innovation cluster	– Business oriented: difficulties to build technological collaborations (especially with Hyundai)
– Strong focus on Green Tech	– Hyundai wants to develop his own national industrial network of suppliers. They don't want to depend upon foreign suppliers
– Officially open to cooperation with Europe	– Intellectual Property rights

Table 27: Summary SWOT Busan/Ulsan

8. CONCLUSIONS

Despite large differences between the selected regions in terms of size, economic conditions, and historical path of development, it is possible to discern some trends and tentative conclusions.

One trend is that the tip of the knowledge iceberg - where one finds the most advanced engineering knowledge in the most research intensive industries and in research universities - appears to be more similar in size and content between different regions than one might expect from just comparing employees, firms, or comparing human capital in absolute numbers. Put differently, the number of top experts within a specific and narrow field of technology in a region is not a one-to-one relationship with the number of people, firms or universities in that region. E.g. the impressing number of new universities in China does not automatically mean that there exists substantially more expertise in, say, laser diagnostics of sprays in advanced combustion engineering research.

For the less advanced parts of knowledge based clusters, differences in size become more apparent. In the 'lower parts' of the iceberg, here represented by people and organizations working in engineering and manufacturing, these parts are to a much larger extent related to the size of organizations and regions. Large automotive regions have often an impressing size in terms of organizations and number of people working in engineering and manufacturing. This represents real differences in terms of capability in large-scale manufacturing and for the ability to test and verify incremental development steps in vehicle product development. A group of 10.000 vehicle engineers will be able to develop a more solid product than do 1.000 or 100 engineers. Still, there are numerous examples in the history of the automobile where it is not the number of engineers that made the transfer of advanced technology knowledge into useful and attractive solutions possible. Also, smaller vehicle manufacturing nations have proven to be able to manufacture advanced vehicle products and to be 'innovative' and provide competitive levels of manufacturing and product quality.

History also shows that economic strength of OEM matters in the case where a firm decides to bring to the market a radically new technology, in a situation where other OEMs still hesitates to proceed. The primary example in road transport may be the decision by Toyota in 1997 to launch a hybrid vehicle technology onto commercial markets. Toyota was at that point in time one of the two economically largest OEMs in the world (the other was GM). The cost is assumed to have been substantial. The reminder of that example is that in order to change vehicle technology more than incrementally (to do larger incremental steps) or even to do 'system change', all alone, one needs substantial economic strength to handle the uncertainties. To do system change in coordination with other actors, however, is the option for most firms and regions? The question then becomes how different regions uses their respective 'tip' of experts in the knowledge system, and how they manage to organize the more shared and distributed parts of the innovation process. Engineering capacity, e.g. in terms of number of engineers in a regional technology cluster, will make a large difference for many development tasks, but not for all tasks. Where instead the ability to transfer advanced knowledge and to create a collaborative innovation systems and cluster will matter. Also smaller clusters and regions can be players and make a difference, become fast follower, or even take a lead. In the area of 'green', 'safe' and 'connected' vehicles there are substantial infrastructure challenges that have to be organized as a shared development between public and private interests.

What this means for regional innovative capacity is not clear from the present study. The Asian regions are substantially larger than the European, but are they 'stronger'? The same question can be transferred to the European (and the SAGE) context. Is the capability and future role for a regional cluster for development simply a matter of organizational and regional size, or is it also, or even primarily, a question of flexible coordination between organizations, i.e., is it a shared development task where the capability to make radical public-private decisions in a regional and national context matters?

The automotive regions in China are governed by the Chinese research and innovation system which is complex and even if the goals for research and innovation to a great extent are set on a national level, provinces are of great importance with various regional innovation systems with their own initiatives and mechanisms. The general picture shows that research is driven top-down and strongly connected to the centrally decided five-year plan. The boundaries between public authorities and the private sector are not as clear as in Europe. A clear cluster structure is difficult to identify since much depends on strong competition between actors both regarding research and innovation and in the Chinese society as a whole.

The region around Shanghai is known worldwide for its automotive industry. The city is a demonstration city for New Energy Vehicles and is well known for competences within e.g. batteries, motors, power electronics and charging systems. There is a strong focus on R&I which is also true for the Beijing region. Beijing as capital city is the decision centre of the country and there is a strong supportive policy for Safe and Green Vehicles.

The Indian economy is the fourth largest economy in the world (PPP) and is one of the most attractive destinations for business and investment opportunities due to huge manpower base, diversified natural resources and strong macro-economic fundamentals. However the present R&D ecosystem is still developing. As a developing nation India places a large emphasis on higher education and the government promotes innovation, but not yet in a clear way with a structured framework and an integrated ecosystem.
The regional cluster in India shows large growth due to general economic growth and the educational system can be regarded as competitive. The resulting capability in innovation in the automotive sector, however, is developing. The extent of industry academia partnership is also limited and availability of funds is an issue.

In Japan the clusters are predominated by the presence of large automotive companies as Toyota and Mitsubishi. Research and innovation is to a great extent conducted in-house within the major companies and the Japanese government's funding to industry is very small (only 5%).There is no clear triple helix structure within the clusters that were investigated but some approaches to establish collaborative research have been started (GReMo in Nagoya) and are strongly supported by current policies. GreMo (Green Mobility Collaborative Research Center) is one example that cluster collaboration is now being applied. GreMo is supported by local and national authorities, university and industry and gathers inter-disciplinary researchers of the Nagoya University within for example materials, ITS and Human Factors.

In general South Korea does not have a clear culture of cluster cooperation. Cooperation between big companies is rare and the link between university and industry with respect to research is weak and mostly based on direct company-university relations. The Korean automotive industry has so far been following technology development focusing on fast

market introduction. In order to become a global technology leader policy makers and industry have initiated new activities to strengthen the countries own innovative capabilities. To strengthen collaborative R&D is one of these initiatives including cluster cooperation between universities and industry. There is also a strong focus to become fourth largest producer of electric vehicles by 2020.

Of the two regions described in this report Daejeon stands out as a very innovative R&D focused region compared to Busan/Ulsan which is more manufacturing oriented, as the home of Korean automotive industry. Daejeon is a very dynamic area with for example KAIST and Innopolis (KAIST has direct relations with the main Korean industries & Innopolis Daedeok represents 15% of National R&D spending) as main actors. Areas where there region is prominent are for example connectivity, energy and vehicle automation.

When looking at the descriptions of the Asian regions it becomes clear that the concept of cluster is not used in the same extent as in Europe. Not only is it difficult to discuss the cluster concept but also to understand the underlying processes steering the regional innovation system. Thus cluster organization dimensions were rated rather low for all regions. The opposite goes for economic ability where most regions in fact are strong. When looking at the innovation and R&D capabilities it is judged that there is a large variation between the regions. This could be due to the fact that the regions selected in the analysis differ a lot in their research focus. Some of them could be defined as research driven automotive clusters while others are more industrial clusters with a manufacturing focus. Tokyo and Nagoya are examples of research driven automotive clusters and are assessed as top regions regarding innovation and R&D. Both Tokyo and Nagoya has the advantage of local as well as global automotive players with strong in-house research facilities.

The benchmark shows that Chinese and Korean regions are strong in policies and drive their research agenda more top-down than the other regions. It seems the cooperation among government, academic, research institutions and industry is regarded to be functional and effective regarding roadmap development for new energy vehicles and green transportation for example. In China, regional authorities tend to respond to state requirements by also developing local and regional development policies, i.e. the strong position of the state through its large technology development programmes, is counter-balanced by local and regional government initiative and development logic that shapes the actual development paths in the details.

8.1. NEXT STEPS

The main purpose of WP7 within SAGE is to select 3-4 clusters and establish a collaboration strategy within the focus areas of green, safe and connected road transport. For this selection two parameters are particularly important. The clusters need to display a strong R&D capability and preferably also have established links or contacts to partners in the SAGE regions. The tentative conclusion for a next step is that the regions of Beijing, Shanghai, Nagoya and Daejeon seem to be particularly interesting, based on the criteria's mentioned above. To strengthen the connections between the SAGE clusters in Europe and the selected research driven automotive regions in Asia, closer contacts will be taken with the aim to develop a strategy and action plan for international collaborations.

The next step within WP7 will also be aligned with the thematic developed within WP4, describing four different focus areas; Safe, Green, Connected and New Business models. The

analysis of regions presented in this report will form the basis when deciding within which focus areas to seek further cooperation.

Interested in knowing more or taking part in the project?
Please don't hesitate to contact us.

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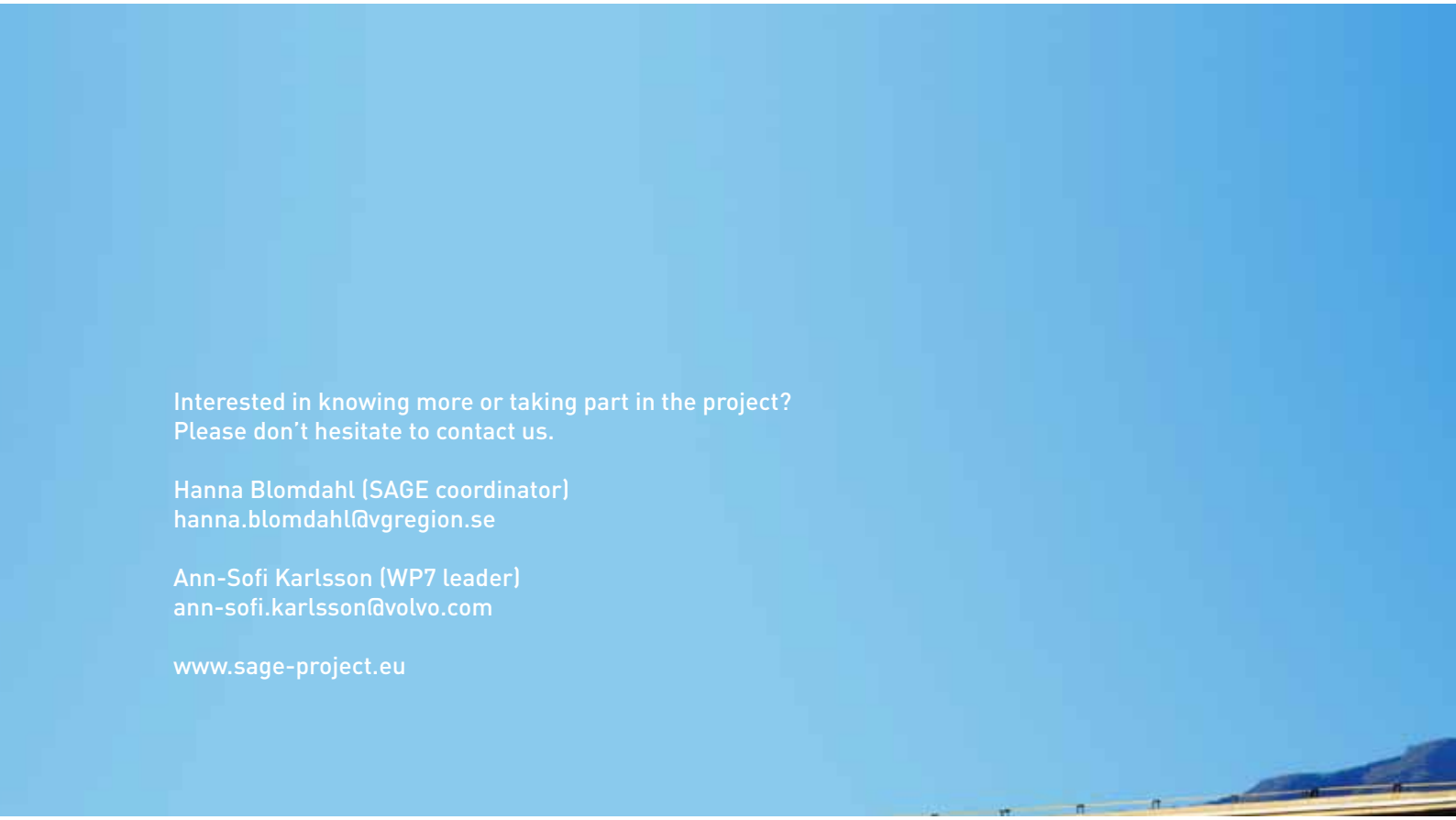

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