Green urban policy:
a comparative study of the promotion of electric cars
in Shanghai and Paris

Master Thesis of International Business Administration

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GREEN URBAN POLICY:
A COMPARATIVE STUDY OF THE PROMOTION OF ELECTRIC CARS IN SHANGHAI AND PARIS

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绿色城市政策：
上海和巴黎电动车推广的比较研究

摘要

本论文通过上海和巴黎的案例研究了可替代能源的转型努力。其关注点在于发展电动汽车的前景。本研究在两个政府及其上级国家政府的框架下探讨了政策、技术和经济发展的更广阔情形。本研究随后评估了上海案例和巴黎案例之间的不同点，尤其是探索可替代能源背后的动机因素。本研究总结认为动机在大多数方面都是相异的，尤其是有关目标到底是生产更洁净的城市空气还是减少有关全球变暖理论的投机性结果的问题。在这一方面，上海寻求前者，而巴黎寻求后者。这一不同点阻碍了两国采纳最优措施的对话。此外，相较于巴黎，上海在制定有关城市人口或甚至是城市服务的严格法规要求的相对自由方面，存在深刻的区别。实际上，巴黎相比上海有着显著更多的自由来制定严格要求。尽管上海必须在没有来自国家层面的实质性支持的情况下行使职能，然而巴黎却几乎拥有来自国家针对环境导向法规目的的完全支持。本论文以提供给上海的关于推进吸引直接外部投资以促进发展和营销城市用电动车的建议作为总结。

关键词：可替代能源，碳排放，电动汽车

GREEN URBAN POLICY:
A COMPARATIVE STUDY OF THE PROMOTION OF ELECTRIC CARS IN SHANGHAI AND PARIS

ABSTRACT

This paper studies the efforts at transition to alternative energy sources in the cases of Shanghai and Paris. Its focus is on the prospect of development electricity-powered vehicles. The study explores the broader state of policy, technology, and economic developments under both governments, including their superordinate national governments. The study then assesses the differences between the case of Shanghai and that of Paris, especially on the matter of the motivation behind the search for alternative energy sources. The study concludes that the motivations are dissimilar in most respects, especially on the question of whether the goal is to produce cleaner urban air or rather to abate speculative eventualities relating to the theory of global warming. In this respect, Shanghai seeks the former, while Paris seeks the latter. This difference obstructs dialogue between the two countries on the adoption of optimal measures. In addition, there is a deep difference in the relative freedom of Shanghai to impose strict regulatory requirements on the city population, or even city services, compared to Paris. In fact, Paris has substantially more freedom than Shanghai to impose strict requirements. While Shanghai must function without substantial backing from the state, Paris has virtually the full backing of state for purposes of climate-oriented regulation. The paper concludes with recommendations for Shanghai to move toward attracting foreign direct investment to aid in developing and marketing electricity-powered vehicles for city use.

KEY WORDS: Alternative energy, carbon emissions, electricity-powered vehicles

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CHAPTER 1 INTRODUCTION

Urban congestion is a serious matter in Shanghai, where the effects of automotive exhaust, coupled with many other pollutants, cause severe visibility and respiratory problems and thereby render the city dangerous to human health. These effects are the product of the rapid industrial growth experienced by Shanghai in recent decades. These effects also create difficulties for business that wish to operate in Shanghai, whose low quality of life discourages many potential expatriate employees from agreeing to locate there. Consequently, the extreme air pollution in Shanghai represents a cost to the city itself, by comparison to what might be the status quo if the city instead presented a highly attractive opportunity for expatriate assignments.

While city congestion is indeed a problem in Shanghai, the emission of fossil fuels is a greater one. Fossil fuels make up approximately 80% of today’s energy generation.[44] Many cities have demonstrated that traffic congestion alone is often tolerable, especially when a city offers alternative modes of transportation, which is indeed the case in Shanghai. However, quality of life begins to suffer palpably when the quality of the environment starts to show signs of extreme environmental stress. At its worst, smog in Shanghai can limit visibility even to 100 meters.[26] This phenomenon is especially serious in the winter, when coal-fired heating contributes substantially to the high level of urban air pollution.[64] Even if one could argue that the lack of visibility in Shanghai had little to do with health, which would be untrue, the impression that it makes on visitors is sufficient to dissuade them from visiting again.

The crux of the problem is China’s booming automotive market. The high rate of annual automobile sales in China since 2008 have made China the world’s largest automotive market.[36] Chinese automobile manufacturers sold over 23 million vehicles in 2014, and they are likely to surpass 50 million by 2020. By 2010, China had come to acquire 24% of the world market of manufactured automobiles.[37] Japan held second place, at 12%, followed by the United States, at 10%. China’s growth in automobile ownership may match the size of the US market by 2025.[26] By 2050, China may have as many cars on its roads as exist in the world at present.

Meanwhile, the advent of the electric automobile has arrived, as testified by the growing popularity of this mode of transportation in many advanced countries today. This development presents two possibilities for the City of Shanghai. First, in the immediate term, a proliferation of electric automobiles on Shanghai's roads would proportionally decrease the amount of carbon emissions experienced in the city.[75] Second, the advent of the electric automobile foreshadows a future of self-driving automobiles, at least in certain special districts.

On the matter of the potential for electric automobiles to proliferate on Shanghai's streets, as an example, if half of all Shanghai automobiles were electric in construction, approximately half of all carbon emissions currently produced by automobiles in Shanghai would accordingly fall by half. While other sources of air pollution would certainly offset this effect, the benefit to Shanghai in terms of improved air quality would be measurable. Over time, as the city continued to increase in the proportion of electric automobiles on the road through a combination of regulation, incentives, and consumer choice, the city's air would become gradually cleaner over time.

Second, on the matter of self-driving automobiles, Shanghai is already in a special position for this possibility. The experimental city of Dongtan may provide an opportunity for experimentation in this domain as well. Meanwhile, to help reduce traffic on especially congested roads, future possibilities may include creating special highways restricted to self-driving vehicles, which might operate in the same manner as toll ways. Beneficiaries of such a system would conceivably be able to bypass the worst urban congestion as a kind of reward for owning self-driving vehicles. This benefit would likely increase the attractiveness of the market for such vehicles and thereby reinforce the beneficial effect on Shanghai's air quality. China's dependence on foreign supplies of key equipment necessary for converting vehicle fleets to new energy sources makes a city like Shanghai vulnerable to market fluctuations in such operations.[14] Limited reliability in securing the necessary supplies increases the perceived cost of conversion for private concerns.

1.1 Statement of the problem

The quality and reliability of electricity-powered vehicles, manufactured in the United States, the European Union, and China, have progressed substantially in recent years.[20] Given the expected marketing benefit that will result from increasing quality while decreasing cost, the shift toward reliance on electricity-generated automobiles in Shanghai is likely to accelerate within the coming decade. The question remains, however, whether Shanghai is able to take advantage of this development. To do so, it may need to begin forming relationships with key industry leaders that are capable of developing new technologies in the area of environmental sustainability. For the businesses in question, there may need to be a converse understanding of the certainty of the benefits that will come from their investment. The sheer pace of progress in this area, in contrast to the rapid growth and concentration of smog in Shanghai, suggest a strategic approach to identifying a vision for Shanghai in terms of the use of electric automobiles, coupled with a credible path for attaining that vision.

The present paper seeks to answer this question. Specifically, it asks what the key dimensions of sustainable technology are in Shanghai, with a comparison by reference to the City of Paris, France. The differences between China and France are so extreme on so many dimensions that it is necessary to sort these dimensions out with great care. For example, the Chinese economy is several times larger than that of France, while Shanghai is also much larger than Paris is. In addition, China is growing at an immense pace, a fact that affects its demand on world energy sources. By comparison, France is currently experiencing minimal growth, a fact that suggests a quite different motivation for France's current pursuit of alternative energies. Finally, the fuel resources available to China are quite different from those that are available to France. This difference may also therefore alter the equation on the matter of how a business that specializes in green technologies may position itself to enter either market.

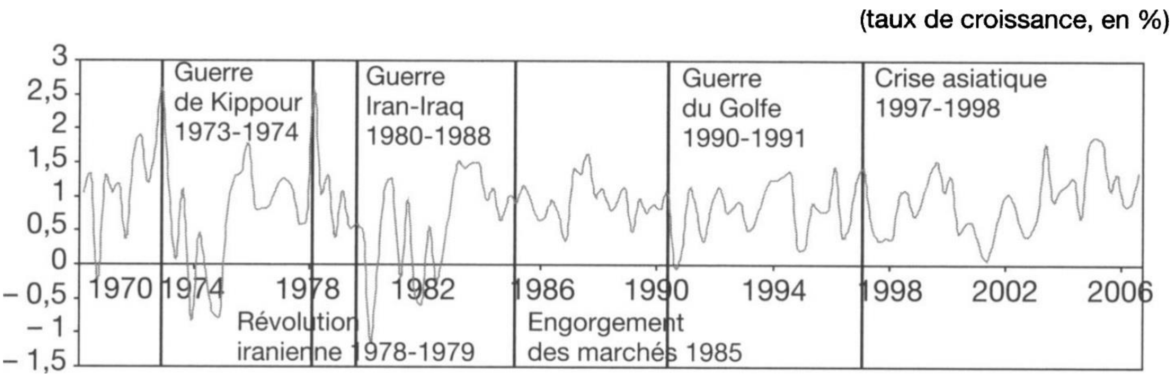
1.2 Significance of the problem

Unconstrained automotive growth in Shanghai poses a self-evident hazard to the city's ability to see to the health of its citizens while attracting further investment. Automobiles contribute approximately 20% of CO_2 emissions to a country's total output, on average.[4] Even so, they are responsible for 45% of all petroleum usage. Insofar as the city remains dependent on foreign sources of fuel during this rapid growth, the result may be extreme vulnerability to exogenous shocks, such as occurred in the mid-1970s in the case of the oil embargo by the Organisation of Petroleum Exporting Countries (OPEC). Exogenous shocks in energy prices, such as the noted oil embargo, have a direct impact on wages and prices in countries that depend on such sources.[7] Strategic responses to such shocks require significant transformations of the affected countries' basis for energy production and consumption.

Agricultural activity consumes approximately 64% of China's total consumption of water resources.[26] Consequently, the toxicity of water, as with high pH balance, is an important focal point of Chinese environmental management. The impact of China's consumption of energy is therefore manifold. Every sector of the economy experiences some kind of effect. Regarding breathability-related emissions, China is currently the world’s leading producer of sulphur dioxide (SO_2).[71] This pollutant, which is a product of massive coal consumption, is one of those identified early in the history of pollution science, which North America and Europe have largely eliminated.

As Figure 1 shows, virtually every conflict that has touched on strategic petroleum resources around the world has caused a shock to national GDP in major countries. More recently, innovations in oil and gas extraction caused a dramatic drop in the prices of oil and natural gas in 2014.[6] European demand for natural gas dropped further during the same year, causing a further decline in the price of that commodity. Thus, reliance on external fuel resources causes considerable national instability.[74]

Figure 1. Effect of war and conflict on GDP due to oil centrality.[5]



Progress in the adoption of alternative-energy technology in urban areas will require fundamental rethinking of modes of transportation and urban infrastructure, whether in China, North America, or Europe.[20] Consequently, it is simplistic to approach a single solution, such as that of developing electricity-powered vehicles, as constituting a significant advance toward the goal of energy usage transitioning. Nevertheless, insights that come from a close comparison between Shanghai and Paris in this singular industrial domain may be of value in extending to other industrial domains. Toward producing such insights, this paper will begin by outlining the energy policies and practices of China and France, respectively, and then focus squarely on Shanghai and Paris. The goal is to discern those criteria that a potential business participant in sustainable energy technology should consider before entering into any such market around the world.

CHAPTER 2 ENERGY IN CHINA, FOCUSING ON SHANGHAI

China's rapid economic growth has placed considerable strain on global energy supplies.[68] This fact seems to have explained the rapid rise in global oil prices during the first decade of the 21st century. Nevertheless, the countervailing force of new technologies, which improve the efficiency of oil extraction from previously difficult media such as rocks and sand, later began depressing oil prices. This effect may have been partially the consequence of the global recession, which began in 2008. If so, then the price of oil should begin to rise again, albeit perhaps slowly, when the global economy has fully recovered. As this occurs, the normal expectation is that the growth in demand from China and India will soften, without actually dropping to zero. Therefore, the need for the fuel is more important than what a normal price increase might be able to offset.

China's current energy efficiency is approximately one-tenth that of Japan.[22] However, China stands to become an important source of energy imports for Japan. Under current projections, Chinese consumption of fossil fuels, as a percentage of global supply, will continue to increase over the coming years.[1] Meanwhile, that of the OECD countries will decline as a percentage. As a result, China's unique mix of fuel sources reflects both China's unique endowments (notably coal reserves), as well as China's most preferred sources of fuel from elsewhere in the world (notably petroleum). Figure 1 shows the unique fuel source make up for several notable countries, including China (CH) and India (IND). As the figure shows, China currently shows unique strengths in five areas, namely, biogas, biomass, combustible waste, hydroelectric power, and solar power. The figure also shows that China is in the lead overall in the use of renewable energy sources.

2.1 Reliance on coal

The rise in carbon-based fuel usage in China is among the most important current considerations in the domain of a global agenda to reduce reliance on fossil fuels.[1] In this sense, China's industrial growth is even more important than that of India in terms of its impact on the nurturance of alternative-energy development in the world. Coal constitutes 27% of primary energy in use throughout the world, second only to oil, which makes up 33%.[65] The use of coal in China has grown fivefold over the past 30 years. This increase in the use of coal has a self-evidently strategic rationale. It involves the likelihood of China's intention to create its own strategic petroleum reserve, to protect the country from future oil shocks. To keep from overusing its accumulating oil reserves, China has aggressively developed its coal industry, but it has simultaneously introduced improved methods over time.[79] By doing so, China has simultaneously grown considerably as a producer of carbon emissions.

China is the third leading country in terms of proven coal reserves (13.9% of known world reserves), following the United States (28.9%) and Russia (19.0%).[65] By comparison, in terms of uranium reserves, which are necessary for operating nuclear reactors, China (4.0% of known world reserves) trails Australia (22.0%), Kazakhstan (11.5%), and the United States (10.3%). Consequently, the cost borne by China to extract coal from the sizable reserves available in China's immense landscape is literally the cost of extraction, rather than that cost in addition to the price of the coal. This observation is because the Chinese Government owns the coal. The difference in cost between coal and petroleum is therefore considerable. China is fully exploiting its cheapest fuel, while building a stockpile of petroleum for the future. In this way, the rapid growth of the Chinese economy has created a unique configuration of demand on world energy sources. The rapid growth of each emergent economy has altered the mix of fuel sources that experiences global demand.[68] China's rapid growth, for example, has placed especially heavy pressure on global demand for coal.

It is also important to point out, on the matter of China's exploitation of its vast coal reserves, that China experiences approximately 20,000 deaths annually in its coalmines, or 20% of the global rate.[65] While this figure may seem extreme, China actually produces approximately 46.4% of the world's coal, so the country's death rate due to accidents associated with coalmining is less than half the average rate in the world. Thus, through these statistics, one can observe two significant facts that reveal something about China's energy strategy. First, China has field a sizable army to the project of extracting coal from its reserves. Second, the pace of the coal extraction work is reasonable, rather than hasty. This latter observation is consistent with the unusually low number of deaths due to accidents in coalmines. On balance, one can therefore surmise that China has a long-term agenda in its coalmining operations. It is going about those operations at a calm pace, rather than with undue haste. It therefore anticipates sufficient coal reserves to supply Chinese industry for decades to come, while it relegates its petroleum receipts to storage tanks.

2.2 Renewable fuels

China announced on 23 January 2015 an ambitious plan for transitioning toward new forms of energy.[43] Among the goals is to keep Chinese petroleum imports under 61% in 2015. Non-renewable energy sources include nuclear and fossil fuels, since these forms of energy production produce significant side effects, either in the form of the toxic output (nuclear) or in that of a decline in actual reserves (fossil fuels).[1] Renewable sources of energy include water (based on currents), wind, and combustible waste products. In 2005 and 2006, China accumulated three times the savings in fossil-fuel usage expected through the development of new technology, by having instead adopted renewable practices since 1990.[1] Thus, while new technologies remain the focus in global alternative-energy promotion, the opportunities available through the adoption of simpler technologies for the promotion of renewable energy seem to remain relatively robust.

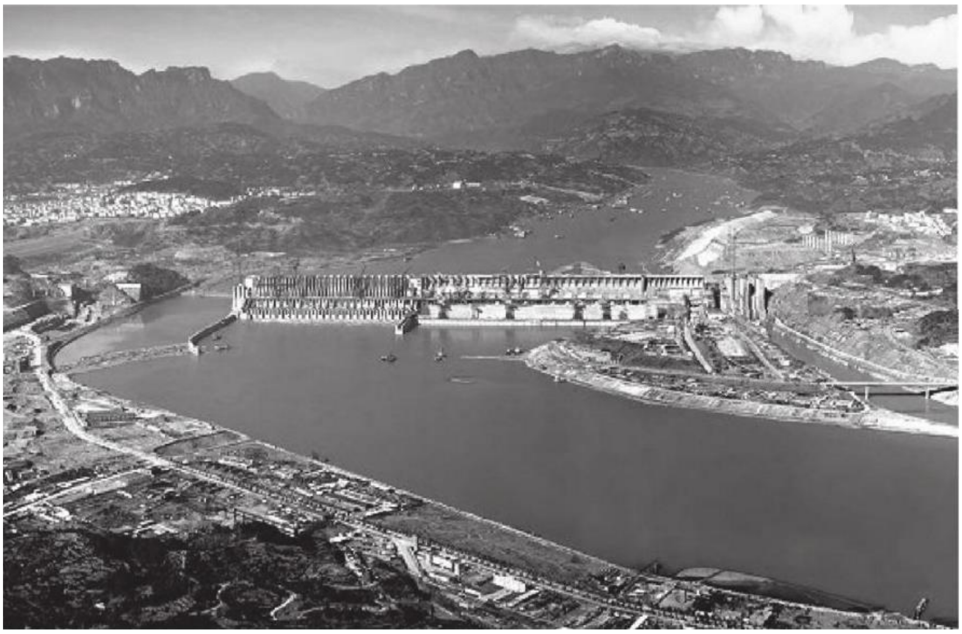
The recycling industry in China amounts to approximately €200 billion at present, compared to €15 billion in France.[23] Thus, while the search for new technology has consumed substantial time and effort among advanced nations, the opportunity for various forms of recycling, including those by which waste material becomes a source of fuel, has yet to reach its full potential. The transition of national policy in China toward sustainable development affected Chinese cities substantially, by promoting the same kinds of innovations as in the 20 or so industrial eco-parks.[23] Features of sustainability from this perspective have mainly emphasized the exploitation of renewable energy in place of fossil fuels for routine purposes.

Some commentators have argued that continued economic growth is simply impossible beyond an ultimate point, because the rate of economic progress is geometric in nature, a fact that renders the risk posed by continued progress increasingly difficult to manage at the same time.[32] Given that this argument assumes a scenario based on current energy technologies, it suggests that new technologies must inevitably emerge, as even reliance on renewable resources will eventually reach a limit.

2.3 Hydraulic energy

Despite the Chinese Government’s admission in 2007 that the Three Gorges Dam project was devastating ecologically, projects continue on the Yangtze River, including 44 large dams.[32] This apparent distinction between acknowledged harm to the environment and insistence on continued building seems to reflect the reality that the production of non-fossil-fuel energy is more important than the ecological effects of large-scale displacement of human populations, towns, and ecosystems. Figure 2 shows the Three Gorges Dam, near Sandouping.

Figure 2. Three Gorges Dam, near Sandouping, China.[32]



The enormous project to transform the Yangtze River by building the Three Gorges Dam, which reached completion in 1994, was highly controversial the world over.[32] In retrospect, the Chinese Government acknowledged in 2007 the significant ecological catastrophe that this advance made. Producing 1,066.1 terawatt hours (TWh) of electricity from hydroelectric sources, China is now the leading world producer of hydraulic energy, primarily by virtue of its many dams.[65] Brazil (411.2 TWh) is next in line, followed by Canada (376.7 TWh) and the United States (258.7 TWh), while hydroelectric production in France (58.1 TWh) is modest by comparison.

2.4 Wind energy

China is currently the foremost producer of wind-generated electricity (26.3% of total world production), followed by the United States (19.7%), and Germany (12.2%).[65] By comparison, at 2.8% of world production, France is in sixth place in wind-generated electricity, tying with Italy in terms of percentage of world production and following both

Spain (9.1%) and India (6.7%). Of the world's leading producers of wind-based energy, Spain has the highest production in *per capita* terms, at 450 MW per million inhabitants, followed by Portugal (385 MW), Germany (359 MW), Canada (150 MW), and the United States (146 MW).[65] Italy follows next (109 MW), then France and the United Kingdom (102 MW each), and finally China (46 MW) and India (13 MW).

2.5 Energy storage

The stockpiling of electricity *per se* is quite challenging, but it forms a major aspect of Chinese initiatives in the long-term reduction of dependence on fossil fuels for its energy needs.[32] Short of such methods of storage, electricity usage must occur very close to electricity production, which is currently the case in France. China currently has 30 GW capacity in step-type energy storage and has 10 GW of additional storage under construction.[65] France has three step sites in three different parts of the country, in addition to a step project in Guadeloupe, anticipated to generate 30 MW.

2.6 Nuclear energy

On a large scale, nuclear power appears capable of producing more electricity with less abundant carbon dioxide output than fossil-fuel-based forms of electricity generation.[32] China's recent financing of two French-made nuclear reactors destined for the United Kingdom reflects a desire on the part of China to improve its nuclear-reactor technology as it continues to build nuclear power plants throughout the country. The prospect of building more nuclear-energy plants continues to evoke strong feelings in the global dialogue over alternative energy.[65] Nevertheless, despite the dramatic possibilities of large-scale failure, the objective evidence suggests that this source of energy is safer than most, at least in terms of the amount of energy realizable per unit of expenditure devoted to the task.

China has two functioning nuclear reactors of the pressurized heavy-water type, known as CANDU (Canada deuterium uranium).[65] These reactors, whose development began in Canada in the late 1950s, rely on fission and are the more traditional variety in existence. China has built two nuclear reactors, known as fast neutron reactors, of 800 MW each, in Sanming.[65] The first of these reactors, installed with Russian assistance, was largely experimental, but it functioned as expected.

China is already exploiting an advanced nuclear-reactor technology, known as EPR, invented by the French.[65] While Finland is building one such reactor in Olkiluoto, and France in Flamanville, China is currently building two reactors using this technology, both in Taishan. China is among several large economies that are actively participating in the construction of an experimental fusion thermonuclear reactor at the Cadarache facility in south-eastern France.[65] This example reveals Chinese intentions to take advantage of technological diffusion to advance its own aims in developing cutting-edge sources of nuclear energy.

2.7 Natural gas in transportation

The City of Shanghai introduced a policy in 1999 to convert all public transportation and taxis to NGV power.[15] The policy specified compressed natural gas (CNG) for the bus systems and liquid petroleum gas (LPG) for taxis. Shanghai subsidized the building of about 110 LPG refuelling stations by 2002.[15] These stations were entrepreneurial ventures, rather than government operations, so they would go out of business if demand were too low. Natural-gas vehicles (NGVs) produce approximately 25% lower CO_2 emissions than traditional petrol, after adjusting for performance levels.[15] Their production of nitrogen and non-nitrogen variants of breathability pollutants is even lower.

By 2008, Shanghai had lost most of its LPS refuelling stations due to low demand from taxis.[15] The number had fallen by that time to only 48 throughout the city. Shanghai's subsidized vehicle conversion program saw 40,000 taxis rendered LPG-usable by 2001.[15] By 2005, however, this number had dropped to about 38,000, as some taxi companies replaced older vehicles with petrol-powered newer ones.

Due to oil's low market price in China, economic incentives to convert vehicles to alternative fuels are weaker than they would be in many other countries.[15] This fact caused difficulties in the natural-gas conversion program for Shanghai's taxis and public transportation to experience losses in numbers of participants soon after the program had begun in 1999.

CHAPTER 3 ENERGY IN FRANCE, FOCUSING ON PARIS

Industrial recycling in France has its roots in 19th-century commerce, in the form of entrepreneurial scavengers (chiffonniers), who would collect reusable materials from industrial waste and move them to other industries, where they might be useful.[23] In that era, the driving force behind recycling was therefore the market price of various kinds of waste products, recast as inputs to other processes. Thus, France began the modern era with a cultural predisposition toward recycling, albeit completely as a; function of market forces.

Despite these origins, France approached the 21st century with an appetite for entitlements and consumption, rather than free-market entrepreneurialism and individualistic resourcefulness. It has taken a generation for France to change its culture of recycling to arrive at a point at which the vast majority of citizens now see recycling as a normal part of life.[23] This process has required a combination of political determination and education in schools.

Total energy consumption in France was approximately 1,370 TWh in 2009, compared to only 480 TWh of electrical energy produced within the country from all electrical-power plants.[32] The remainder is in non-electricity forms, including locomotion (air, rail, and surface) and manufacturing. The mean energy consumption per inhabitant in France is approximately 22,100 kWh, or nearly half that consumed by the average inhabitant in the other 32 richest nations of the world (viz., 55,000 kWh).[32] Although the world average per inhabitant is appreciably lower than the French figure, the expectation of continued development of quality of life around the world suggests the French figure to be a reasonable target for advanced countries to pursue, as they improve their energy technologies.

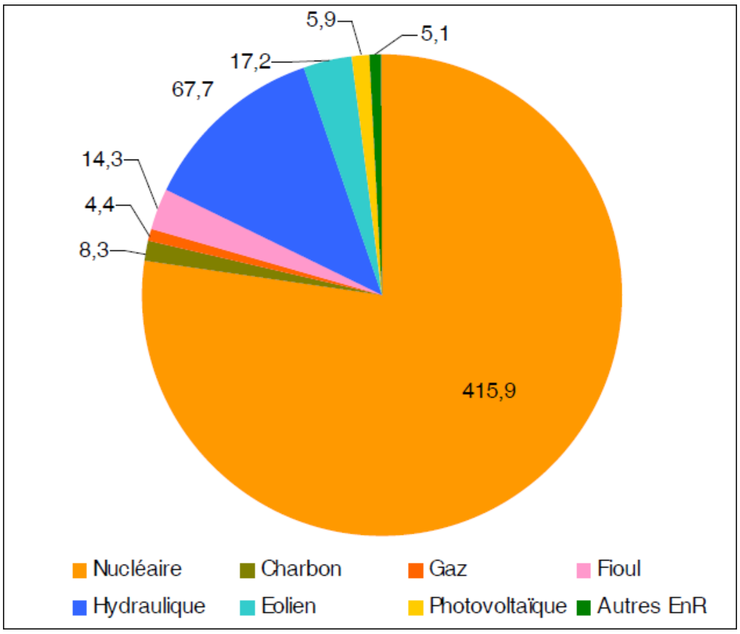
3.1 Reliance on electricity

French reliance on combustible sources of energy is currently at the same level as its reliance on hydraulic energy, namely, 62 TWh per year (2009), or about 11.4% of its entire electrical needs.[32] This low reliance on combustible sources is a direct product of its heavy reliance on nuclear sources, which amounts to 410 TWh per year (2009), or about 75.6% of its needs. France uses roughly the same amount of combustible fuel for its electrical needs as for its transportation needs, the latter in the form of automobile power.[32] In virtually all other countries, reliance on fossil fuels for electricity is considerably greater, by many multiples, than the reliance on fossil fuels for automotive needs.

Normal variation in electricity usage in France moves from an early-morning low of approximately 30,000 MW to an early afternoon high of approximately 50,000 MW.[32] Seasonal extremes, such as during an unusually cold winter, can push electricity demand as high as 100 GW, or double the usual daily maximum rate. French demand for petroleum refining dropped 14% between 2008 and 2014.[8] This drop is a direct reflection of a parallel decline in reliance on petroleum, especially the imported variety, in recent years.

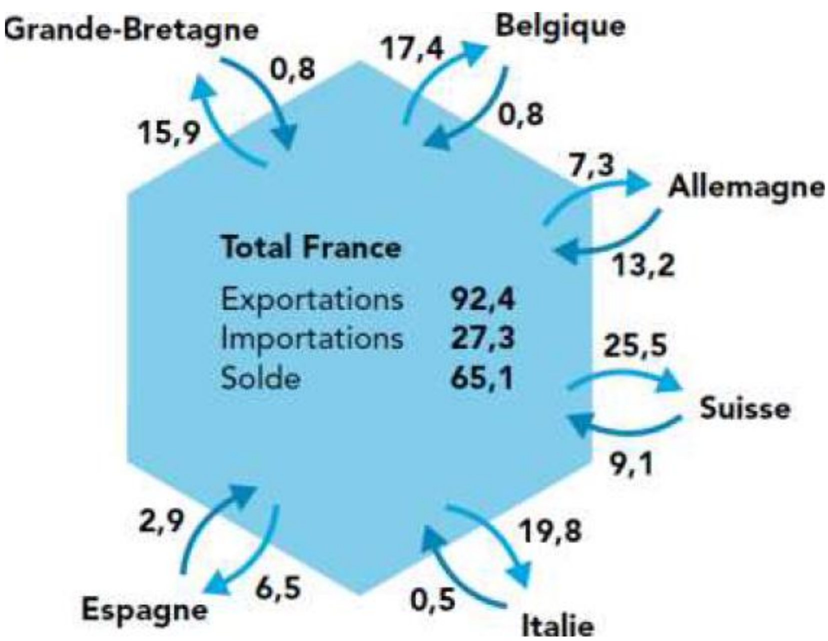
France’s electricity consumption dropped between 2001 and 2011, from 269 million tonnes-of-oil equivalent (Mtoe) to 259 Mtoe.[65] Nevertheless, France had to import 51% of its fossil fuels during this period, simply to meet national demand. Total French electricity production reached 539 TWh in 2014.[10] This level represented a decline of 1.8% from the previous year. Figure 3 shows the subdivision of French electricity production from all sources.

Figure 3. French electricity production, 2014 (TWh).[10]



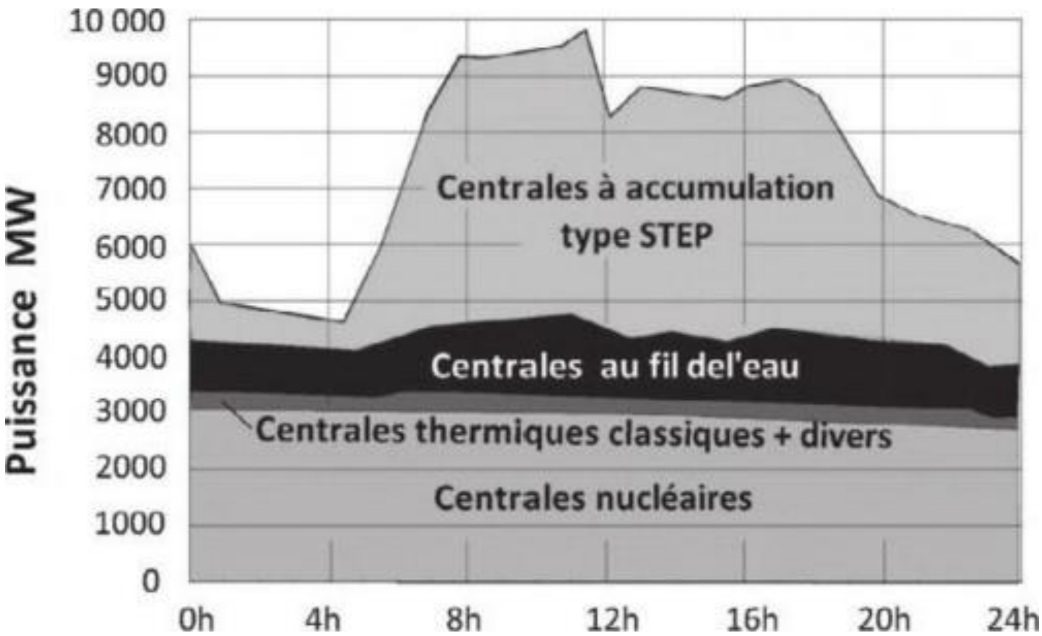
Approximately half of France's energy usage is in the form of electricity.[65] The remainder consists of the burning of fossil fuels for direct purposes, such as automobiles, airlines, rail transportation, and industrial purposes. France produces such a large amount of electricity, at relatively low cost, that it is able to export most of it. Figure 4 shows the flow of imports and exports in the electricity trade with neighbouring countries.

Figure 4. Energy trade balance with France, 2014 (TWh).[10]



Approximately half of France's energy usage is in the form of electricity.[65] The remainder consists of the burning of fossil fuels for direct purposes, such as automobiles, airlines, rail transportation, and industrial purposes. Meanwhile, France also manages its electricity storage using the most efficient available systems, notably the STEP system. A STEP system (stations de transfer d'énergie par pompage) is a method of storing large amounts of electricity, on which both France and Switzerland are currently relying in increasing measure over time.[32] STEP systems dramatically increase the reliability of electricity provision through the volatile patterns of daily energy usage, as daytime usage typically rises to double nighttime usage in normal urban environments. Figure 5 shows the normal daily pattern of electricity usage and storage in conjunction with a STEP system.

Figure 5. Daily pattern of electricity provision using a STEP system.[32]



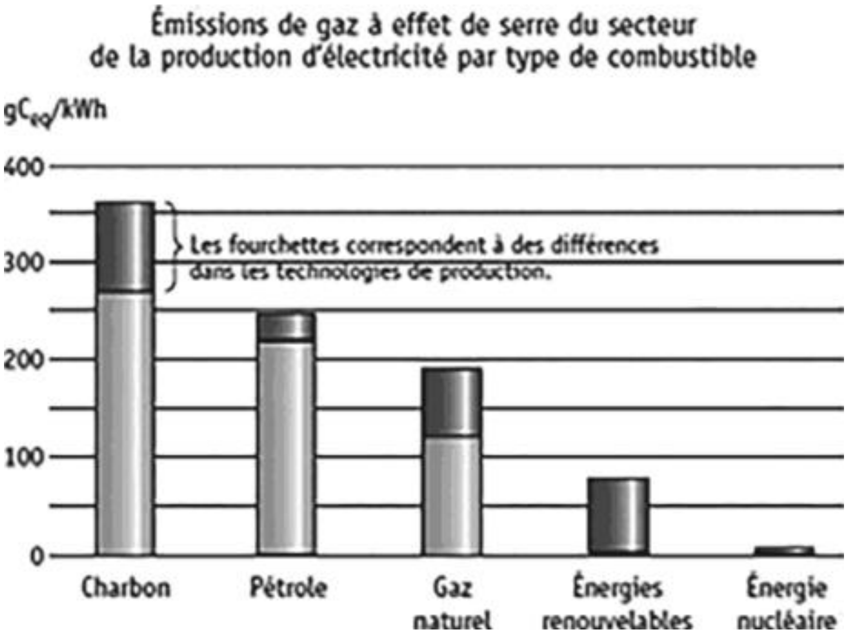
3.2 Carbon emissions

In view of France's relatively light reliance on carbon-based fuels for non-transportation purposes, transportation is responsible for 33% of all CO_2 emissions produced by the country.[9] Thus, France's progress so far in terms of reducing carbon emissions has focused almost completely on non-transportation energy innovations. A total of 61% of petroleum products serve transportation purposes, both in France in particular and in the world in general.[9] In turn, transportation is responsible for approximately 16% of all CO_2 emissions in the world.

Automotive traffic in urban areas produces 40% of CO_2 emissions in the European Union.[25] Given France's heavy reliance on nuclear power, the proportion of CO_2 produced in French cities is mathematically higher than this figure.[18] Ethanol reduces carbon emissions at different rates, depending on its vegetable provenance.[9] As measured in France, the greatest reduction comes from palm oil (76%), followed by beets (66%), rapeseed (59%), corn (56%), wheat (49%), and finally sugar cane (47%). Ethanol is only 75% as efficient as petrol in producing energy.[16]

The concept of carbon intensity is a mathematical function of carbon emissions per unit of GDP, hence per euro or dollar, in effect.[68] European countries' carbon intensity is currently around 0.3 kg CO_2 per USD, while the North American figure is somewhat higher, at 0.5 kg CO_2 per USD. Figure 6 shows the relative amounts of carbon emissions that emanate from a given energy-equivalent quantity of carbon, petrol, natural gas, renewable energy sources, and nuclear energy.

Figure 6. Carbon emissions by form of electricity production in France.[32]



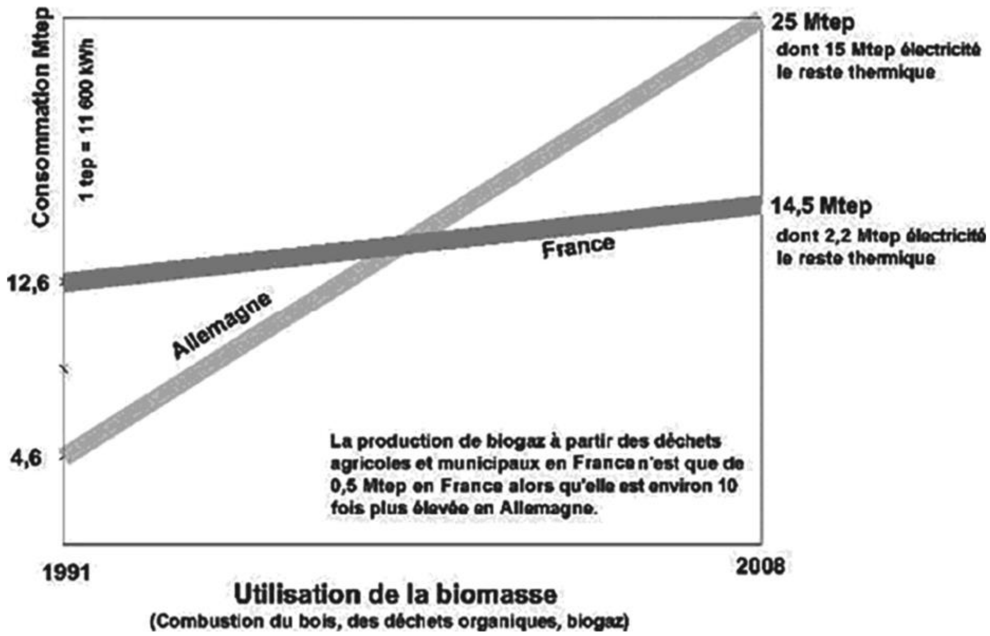
3.3 Recycling

For every tonne of waste products that France recycles, the result is a reduction in CO_2 emissions of approximately the same number of tonnes.[23] Contrarily, of course, the use of waste products to generate electricity causes virtually no reduction in CO_2 emissions at all, compared to what would occur if the same waste instead went to ordinary waste incinerators.

France is the eighth largest recycler in the world, recycling 64% of waste products each year.[23] Bigger recyclers include Denmark, Poland, Germany, Czech, Italy, Slovenia, and the United Kingdom. France makes maximum possible use of waste products from already recycled materials, by channelling them for use in industrial solvents, metal products, paper, and glass.[23] In these secondary uses, those waste products amount to between 26% and 60% of total inputs.

By comparison, Germany's development of technologies necessary to convert urban waste into electricity has reached a level at which 60% of its biomass, including waste products, now become electricity, rather than being subject to ordinary incineration.[32] France has achieved only a 15% efficiency level in this respect. Figure 7 shows a comparison between France and Germany in terms of the growth in biomass usage since 1991.

Figure 7. Growth of biomass usage in France and Germany.[32]



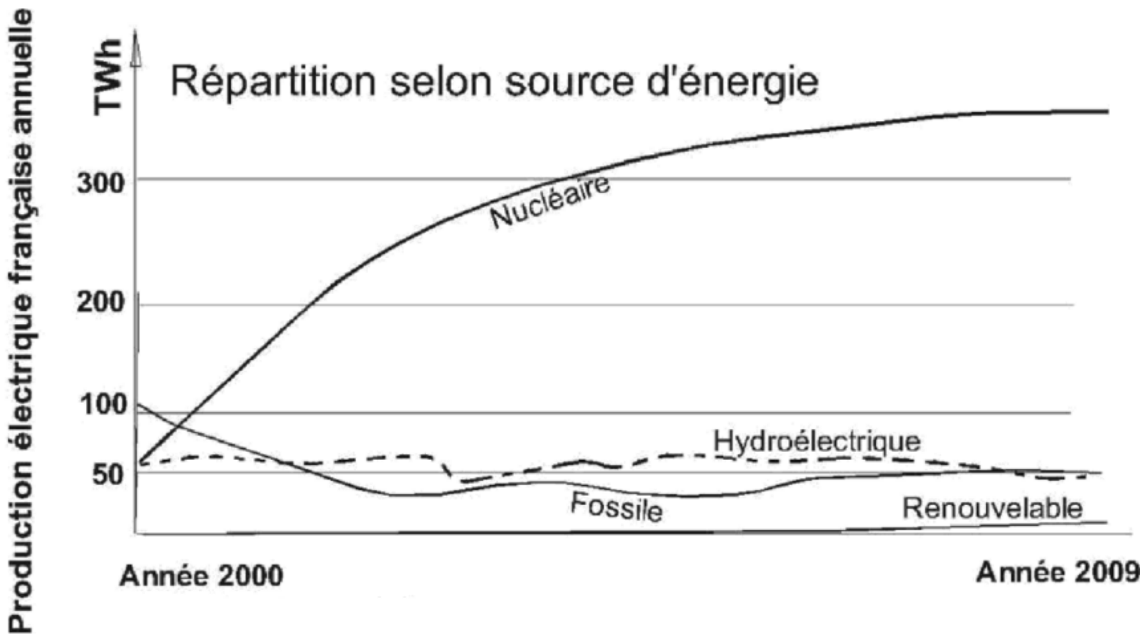
3.4 Nuclear power

France uses nuclear power for approximately 75% of all of its electrical needs, compared to 26% in Germany.[32] Nuclear sources of electricity generation had reached 77% of total French electrical production by 2014, representing an increase of 3% from 2013.[54] Although the aspiration in France is to decrease total reliance on nuclear energy over the coming decades, this increase was due to an increase in the average reliability of nuclear power plants, which had reached 80.9% by then.

The generation of nuclear power is a direct function of the growth of the French economy.[52] Consequently, any policy to shift away from nuclear power runs contrary to the expected needs of an increasing complement of electrically powered vehicles in a city like Paris. France’s rapid growth in the construction of second-generation nuclear-power plants was a direct result of the oil shock of the mid-1970s.[65] Second-generation nuclear power uses enriched uranium as its fuel.

The average lifespan of a French nuclear reactor is 23 years.[65] France intends to reduce its reliance on nuclear power to generate electricity, to 50% of total electricity production, by 2025. By 2008, France had 58 pressurized-water nuclear reactors (PWRs), known as the second-generation type.[68] These constituted 13.2% of all such nuclear reactors in the world. Figure 8 shows the evolution in the use of nuclear power since 2000, in terms of TWh.

Figure 8. Profile of nuclear and other energy sources used in France.[32]



With nuclear power naturally comes radioactive waste. This has been the only significant drawback for French nuclear policy. France recognizes four classifications of radioactive waste, distinguished in the form of very weak, weak, moderate, and high activity.[23] Waste in the very weak category consists of parts from defunct nuclear facilities, rather than actual radioactive fuel.

France produces approximately 25,000 tonnes of very-weak radioactive waste.[23] By law, such waste requires storage along with other types of non-radioactive waste deemed potentially harmful to the environment. Nuclear-waste products in the weak or moderate category consists of tools and equipment previously used in a nuclear facility in high-risk jobs.[23] Much waste of this kind also comes from hospitals or research centres, rather than nuclear-power stations.

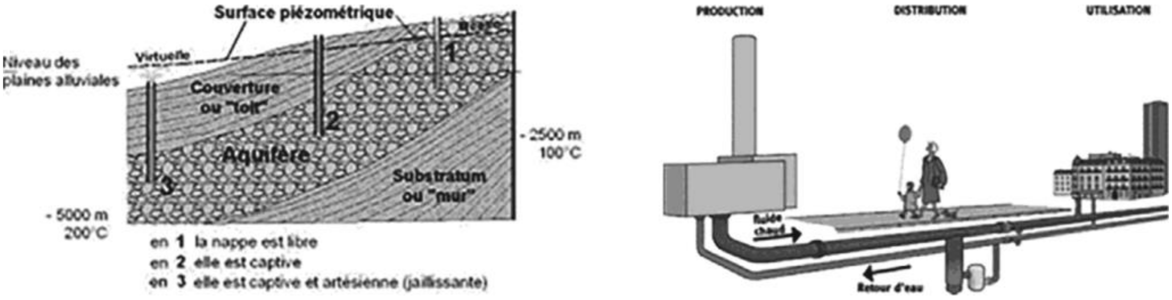
France's special storage facility for weak to moderate radioactive waste, at Soulaines-Dhuys dans l'Aube, is the largest in the world.[23] This facility has a capacity of approximately one million cubic metres, which provides enough space for 76 years of waste of this kind, at the current pace of waste production. Radioactive material of high activity, along with that of long-life moderate activity, has nowhere to go on earth except currently in special storage facilities, while it awaits a more permanent solution.[23] About 99.9% of this material in France comes directly from nuclear-power plants, primarily in the form of spent fuel rods.

3.5 Geothermal energy

In response to the oil shock of the mid-1970s, Paris began aggressively developing geothermal wells to help provide heating for city residents, as an alternative to the use of petroleum derivatives for the same purpose.[32] The drop in oil prices after 1986 brought new development of this kind to an abrupt halt, but two-thirds of the pumps built during that period remain in use. Germany invests considerably more than France in heat pump technology, to compensate for the greater cost of natural gas in Germany.[32] This example shows clearly that technological development of new energy sources benefits directly from increases in costs of alternative sources.

While geothermal energy is valuable in Paris as a natural source of heating residences, the high temperatures (approximately 200 degrees Celsius) at depths of approximately 5,000 meters simultaneously serve as a lucrative source of turbine power.[32] The ability of Paris to power turbines using natural subterranean heat sources provides the potential for creating energy at minimal variable cost, after the necessary investment in infrastructure. Figure 9 shows the general principle behind the use of geothermal energy in the French context. The image to the left shows the value of sending a pump sufficiently deep to tap into naturally boiling water. The image to the right shows how a geothermal pump system may power the recycling of urban waste, thereby using a natural source of energy to produce even more energy.

Figure 9. Geothermal and waste combustion energy, as structured in Paris.[32]



The disadvantage of geothermal sources is that underground rivers are often only seasonal in nature, hence unreliable for year-round usage.[32] This limitation has held back development of geothermal sources in Paris, in contrast to Switzerland, where underground rivers have more often proved to be perennial in nature and therefore highly reliable as alternative sources of heating or turbine operation. Worldwide geothermal energy production reached 70 TWh by 2005, or 6 Mtoe.[68] Of this quantity, French production in the Parisian and Aquitaine basins accounted for 2.2%, or 0.13 Mtoe.

3.6 Alternative energy sources

On the European continent, France appears to hold the greatest potential in exploiting shale gas, at approximately 30% of European supply.[22] Despite this advantage, the French Government outlawed fracking as an industry practice in 2011 and is currently waiting for alternative ideas for exploiting its shale resources. France outlawed hydraulic fracturing (fracking) as a way to secure natural gas, under the law of 13 July 2011, which took effect in 2013.[65] France has experimented with ideas for clean fracking since that time.

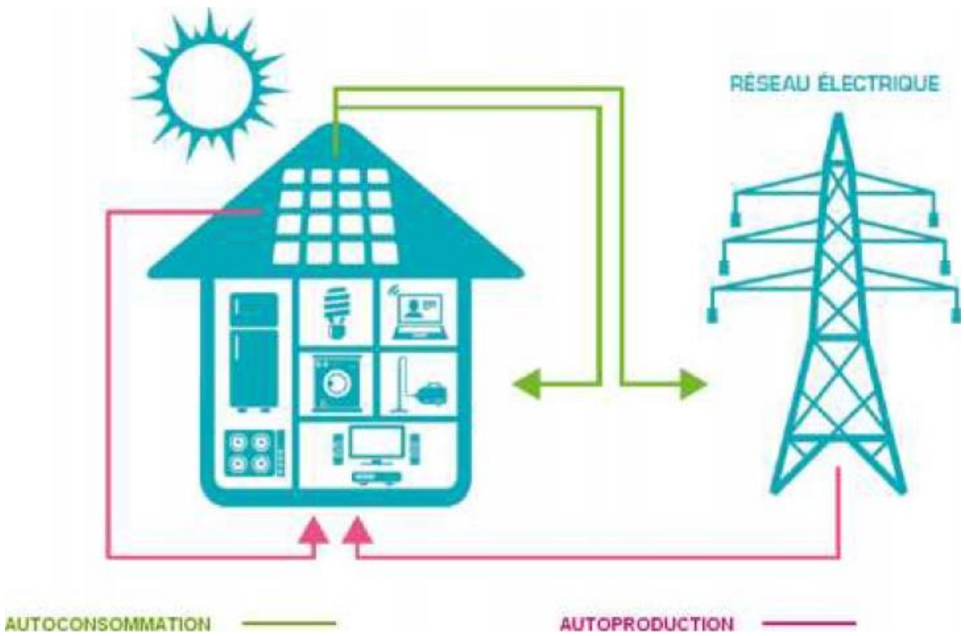
Wind power is also available in France, which hosts numerous wind turbines throughout the country, including several offshore locations. The Eiffel Tower has provided a high-visibility example of the potential of wind power.[29] The tower now includes wind turbines within its structure, which supply enough power to support all commercial areas of the tourist attraction.

Hydroelectric power constitutes 19% of global energy production.[65] Mostly generated from dams on rivers, hydroelectric power in France makes up 20 GW (13%) of

French electricity consumption. Hydroelectric power in France comes in two forms, namely, dams and tidal power.

Finally, solar energy is of self-evident importance in France as well. This resource comes in two essential forms, namely, the standard industrial solar collector fields, which take advantage of empty land area to draw the sun's energy undisturbed, and a household-based variant, which exists in only a small proportion of residences. The principle behind household-based solar energy is a tie-in to an electrical grid.[63] This arrangement enables the household to receive credit for excess electricity generated, beyond household needs, from which the larger community therefore benefits. Figure 10 shows how household-based solar energy works in this scheme.

Figure 10. Scheme for industrial sharing using household-based solar energy.[63]



The amount of solar energy that France could collect, under the hypothetical assumption of using all available surface area in the country, is roughly one thousand times what the French nation actually uses.[32] Although it is naturally unreasonable for France to dedicate its entire surface area to solar collection panels, the potential of this minimally tapped energy resource is impressive.

3.7 Electricity-powered vehicles

In 2010, the French Government announced plans to purchase at least 50,000 electrically powered vehicles.[20] Some estimates of the actual quantity purchased went as high as 100,000. Electricity-powered automobiles currently support relatively short distances between recharges.[68] Standards in cities may tolerate 30 km, as in the case of 60% of news vehicles in France, but these distances continue to increase as battery life and engine technology continue to improve.

Part of the ambitious plan of Ecology Minister Ségolène Royal is to enable every French citizen somehow to acquire an electricity-powered automobile.[66] France currently has approximately 30,000 electricity-powered vehicles in use, which constitutes 0.08% of all French vehicles. Part of the French proposal to increase the number of electricity-powered vehicles on French roads is a provision for governmental agencies to transform their motor pools into 100% electricity-powered vehicles.[66] A logical adjunct to this provision would be an incentive for corporations to transform corporate fleets in the same way.

Although electricity-power automobiles may reduce pollution in cities, they may do little to curb total carbon emissions if the electricity that they use comes from carbon-intensive electrical-power plants.[46] In France, the shift to electricity-powered automobiles effectively signifies a transition toward greater use of nuclear power, as long as nuclear power remains the dominant way to product electricity in the country.

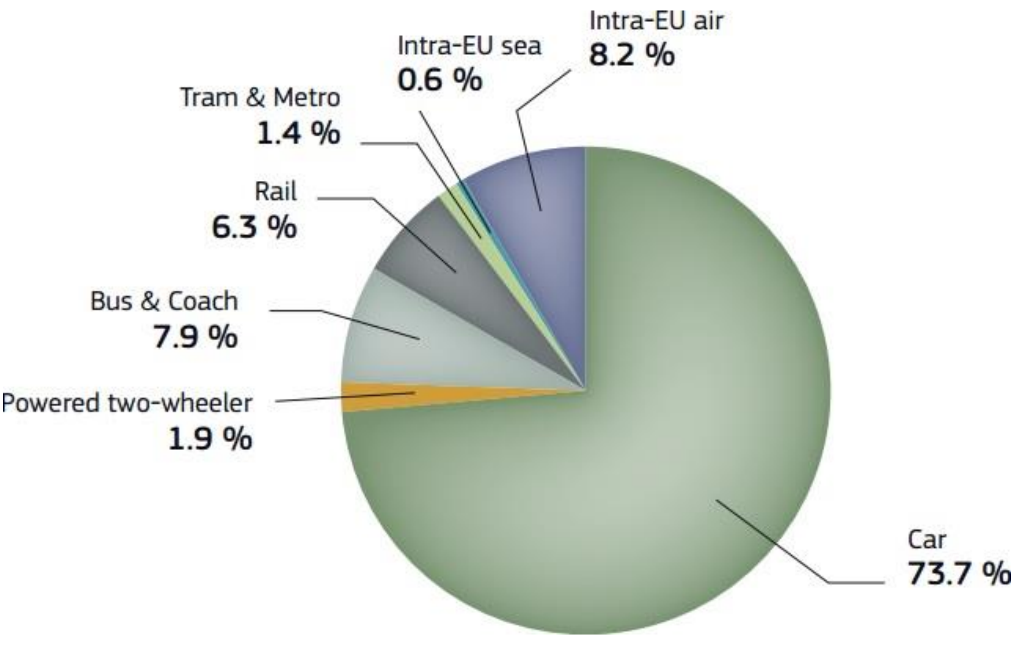
The French proposal, which the Assembly has now passed, calls for a national objective in hybrid vehicles of two litres of petrol per 100 kilometres of distance.[69] As an overall average, applied to corporate fleets under regulation by the state, this benchmark would logically push corporations to add electricity-powered vehicles to their fleets alongside hybrid vehicles, to achieve the targeted average. About 2.2% of all French transportation uses electricity for propulsion, compared to only 1.0% worldwide.[9] By comparison, French transportation uses natural gas in only 0.2% of vehicles, compared to 3.8% worldwide.

The current proposal by French Minister of Ecology Ségolène Royal includes refitting older buildings to accommodate alternative energy and offering tax credits to property owners who invest in such structures on their own.[13] The proposal also insists on increasing the number of electric-automobile recharging facilities to seven million by

2020, up from today's 10,000. The French proposal seeks to reduce non-transformed waste volume to half of current levels within a decade.[13] It also seeks to increase the use of renewable sources of electricity from 13% of total French energy production today to a new goal of 30% in 10 years. The French energy proposal anticipates reducing reliance on nuclear energy to 50% of total French energy production, from today's level of approximately 75%.[13] This part of the proposal contradicts the goals related to reducing carbon emissions, however, because France's heavy reliance on nuclear energy thus far has been the reason that the country is so far ahead of the rest of the world in reducing carbon emissions.

Pursuant to a law promulgated in October 2009, France has announced intentions to have two million electrically powered vehicles in service by 2020.[20] This law received considerable support for environmental groups. An estimated 27% of all vehicles sold in the European Union by 2025 will be of the electrically powered variety.[20] This figure represents between 14 and 24 billion euros. As Figure 11 shows, a full 73.7% of all transport that occurred in the European Union in 2010 was in the form of passenger vehicles.[24] Air travel is next in importance (8.2%), followed by bus (7.9%), and then rail (6.3%).

Figure 11. Distribution of transport types in the EU (2010).[24]



CHAPTER 4 COMPARATIVE ANALYSIS OF SHANGHAI AND PARIS

Since the aim of this study is to offer recommendations for decision making in Shanghai, this analysis will mainly focus on the Chinese perspective, in light of the foregoing discussion of the situation in Paris. This analysis will follow the PESTEL model. This model focuses attention on six areas: (a) political considerations; (b) economic considerations; (c) social considerations; (d) technological considerations; (e) ecological considerations; and (f) legal and regulatory considerations. Moreover, while Parisian policy is largely that of France as a whole, given the minimal distinction between the two, Shanghai policy is largely independent of that of China as a whole, except as it affects automotive manufacturing and fuel efficiency standards.

4.1 Political considerations

The main political consideration concerns the difference of opinion implicit in the distinct approaches to energy transition taken by Shanghai and Paris. While Paris focuses on long-term, speculative effects from current energy usage, Shanghai looks at the palpable effects of current energy usage on public health. Given the rapid rise in China's consumption of fossil fuels, it is clear that China's full participation in any global agenda is critical to success.[1] Otherwise, the mature economies of the world may well transition away from fossil fuels on their own, only to produce a net price decline for the benefit of China and India. China, Brazil, and India are all participants in G20 dialogues.[20] Operating through the diplomatic mechanism of the G20 seems therefore to be an appropriate medium through which to harmonize global policy in the transition away from fossil fuel usage.

China's rapid economic growth, which necessitates rapid growth in the consumption of fossil fuels, makes it incumbent on Chinese negotiators in diplomatic circles to secure significant benefits from global green-energy initiatives, rather than have to face immediate impediments to growth due to the hasty adoption of expensive new technologies.[20] For this reason, China has pushed for whatever accommodations might be forthcoming from the United States in terms of relaxing expectations of how quickly the country is willing to transition to green energy. In general, China and India have opposed plans solely intended to address greenhouse gas production, despite the general attitude among these nations' leaders in agreement with the concept of anthropogenic global warming.[65] Only the United States has voiced strong opinions against the adoption of restrictions against greenhouse gas emissions based on the actual lack of empirical evidence to suggest that human beings might be causing climate change.[56]

The BRIC nations, which consist of Brazil, Russia, India, and China, together constitute a highly important economic segment in the world, in view of the combination of their rapid economic growth and consequently their rising use of conventional fuels.[65] These countries are also among those that usually try to circumvent restrictions, at least as enunciated under global agreements, related to the transition to new forms of energy. The fact that all of the BRIC nations have this characteristic in common effectively nullifies the argument that China is alone in perceiving the necessity to do. Indeed, all BRIC countries perceive the delicate nature of their current growth rates as a vulnerability. A hasty international agreement to curb economic growth would cause more harm to these economies than it would to others. This observation provides validity for the stance adopted by China in this regard. The rapid pace of Chinese economic growth renders any consideration of hampering economic growth anathema to its interests, especially in view of the fragility that Chinese observers see in their own economic condition.

The refusal by China and India to participate in the 2013 COP talks in Warsaw, along with Japan's change of mind about the terms of the proposals presented there, sent a strong signal to world leaders regarding the fragile nature of global agreements to promote a transition to alternative energy sources.[65] However, in this same demonstration of reticence among some of the key world nations whose participation is critical to success on the global front, a belief in the substantive nature of such agreements was evident as well. That is, had the United States, Japan, and the BRIC countries seen the agreement as a mere formality, which they could readily ignore upon their return home, much less harmony would have been visible in their reaction to it. This fact lends credence to the seriousness of the agreement.

A worldwide carbon tax would greatly upset China's economic growth and propel the country on a desperate search for technological alternatives, such as by ramping up its growth in nuclear reactors.[32] For this reason, China has so far adopted a highly pragmatic stance in international negotiations in the area of green energy, effectively refusing to give up any current advantages except in exchange for more lucrative returns from other countries, notably the United States. Above all, China seems quite insistent on using up all of its coal reserves, if it believes this end is achievable without causing serious harm to the environment. Only by pursuing this strategy, can China build a reliable supply of petroleum reserves and thereby free itself from dependence on foreign countries for the viability of its economy.

4.2 Economic considerations

On the economic front, two pressures are apparent. First, there is the matter of Shanghai's rapid growth. This fact necessitates a higher level of consumption of energy than normal. Second, there is the subjection of Shanghai to market forces, far in excess of what occurs in Paris. While Paris, in conjunction with French national policy, can largely ignore market forces when regulating vehicular life in the city, Shanghai must work with market forces to the same end. The challenge is therefore much greater in Shanghai than it is in Paris.

Experts project that China, Brazil, and Russia will be among the top six world countries in terms of GDP, adjusting for purchasing power parity, by 2020.[65] This rapid growth among these large, emerging economies suggests an equally rapid rise in the use of fossil fuels in these countries. Moreover, due to the rapid rise in GDP in these countries, the actual fuel consumption as a proportion of total world consumption will be significantly greater than it would be if their growth rates were similar to those of North America or Europe.

China surpassed the United States in 2010 as the world's leading consumer of energy in the world.[65] This timing, when China trailed the United States significantly in GDP terms after adjusting for purchasing power parity (at $10 trillion *versus* $14.6 trillion, respectively), suggests a relatively inefficient use of energy during the years leading to that time. This apparent inefficiency is a function of the rapid growth rate itself. That is, Chinese fuel consumption will be greater, as a proportion of global fuel consumption, while the Chinese economy is rapidly growing, than it would be if the Chinese economy were growing slowly, while nevertheless being the same size. Indeed, the demand for carbon-based fuels in China rose 10.6% in 2005.[1] Observers have noted that the rapid rise in Chinese fossil fuel usage over time has virtually nullified any savings that European countries have garnered in their own efforts to transition away from fossil fuels.

With 1.34 and 1.22 billion inhabitants, respectively, China and India represent a sizable need in terms of energy usage.[65] For this reason, any decision made by either country that affects its access to energy resources will have a much greater effect than the same decision made by a smaller country. In fact, rapid industrial growth in emerging economies intensifies the demand *per* unit of GDP on energy resources.[68] Nevertheless, China's current demand for energy actually represents a drop in the rate of growth over time, at 0.23 toe per $1,000 of GDP in 2004. If this drop is meaningful, it suggests that China's growth rate has already hit is maximum and has since been declining to some degree. Although China has continued to outpace the rest of the world in total energy consumption due to its still relatively high rate of growth, it will have increased its consumption at a decreasing rabid rate with each passing year.

Declining oil prices have more than merely provided China and India an opportunity to slow their development of alternative fuels; rather, the phenomenon has instigated a more rapid rise in these countries' demand for fossil fuels, thereby offsetting gains made in North America and Europe.[1] Thus, the objective evidence so far shows that any global policy of promoting alternative fuels requires the full participation of China and India, to ensure that the expense undertaken by the mature economies of the world does more than merely transfer value to large, rapidly developing economies. Otherwise, the only way to incentivize China and India to reduce their dependency on foreign oil is to wait for global oil prices to rise.

In fact, the currently low global price of oil is largely a consequence of efficiency measures adopted throughout North American and European industry, coupled with national energy usage policies in those countries.[1] Specifically, the new technologies for extracting oil from tar sands, in addition to technologies for extracting natural gas from rock formations, have supplemented the world supply of fossil fuels in unexpectedly great capacity. This increase in capacity seems to interact with the global recession to magnify a modest drop in the demand for oil into a very large one. However, this same drop in oil prices has incentivized both China and India to rely more solidly in the short term on fossil fuels, rather than more aggressively seeking to develop energy alternatives.

The reason for China's rapid rise in fossil fuel consumption is the country's rapidly growing economy.[1] By comparison, the OECD countries have experienced minimal growth in the past decade, hence minimal growth in the demand for fossil fuels. If one calculates the correlation between the size of national economies (GDP in PPP terms) and the level of consumption of world energy sources, one finds an almost perfect correlation. Thus, the size of the national economy is an accurate predictor of the amount of fuel resources the country will consume. The Chinese economy has grown at an average rate of approximately 9% per year since the 1980s.[2] As China has grown in this way, the effects of prior damage to the economy, coupled with increasing consumption of fossil fuels to sustain the rapid growth rate, have become apparent.

The more rapidly an economy is growing, the more energy sources it will consume. This effect, purely from the rate of growth, complements that of the size of the economy as a whole, to provide a more accurate predictor than is the case using the size of the GDP alone. Consequently, if China and India are rapidly growing, in addition to being large economies per se, then the amount of energy that they consume will be a function of both GDP and GDP growth rate combined. Given this observation, it is clear why both countries have opted out of international protocols to limit carbon emissions.

The rapid rate of growth of China, India, and Brazil represents a stronger force in the world than the much more modest efforts on the part of the mature economies of North American and Europe to cut their reliance on fossil fuels.[65] That is, China, India, and Brazil are growing so rapidly, as very large economies, that they must consume vast amounts of fuel. In compensation, the mature economies of North America and Europe have sought to cut their total carbon emissions. However, it is impossible for them to cut their emissions so thoroughly as to make up for the vast amounts of carbon-based fuels consumed by China, India, and Brazil. Consequently, inequalities in national economic growth rates have continued to frustrate agendas of global energy policy.

As a point of contrast, China consumed only 6.2% of the world's available energy in 1980.[1] By comparison, the United States consumed 27% at the same time. These differences were closely in line with the actual size of each nation's GDP. China also had yet to begin its spectacular growth that early in history, as Premier Deng Xiaoping was only beginning his career at the time, as a significant leader in the Chinese Government. Therefore, without the enhancing effects due to rapid economic growth, the proportional difference between the US and Chinese GDPs in 1980s was closely identical to the proportional difference between US and Chinese fuel consumption.

China sustained approximately 10% annual GDP growth for several years.[32] Its current growth rate has dropped by a few percentage points in the most recent accounting, however, and it is likely to drop further due to the lingering aftereffects of the global recession. The relaxation in China's annual growth rate should additionally bring the Chinese consumption of fuel as a proportion of world consumption more closely in line with that which one would expect from the sheer size of the Chinese economy, without the enhancement of that effect due to rapid economic growth. China currently consumes approximately 15% of the world's total energy usage.[1] This is very close to the European Union's 16%, although the United States continues to lead the world in energy usage, at 23%.

Rapid economic growth eventually puts pressure on agriculture, especially in terms of promoting the cultivation of types of fish or livestock that require the least amount of grains.[68] This transition, which has indeed occurred in China in the form of fish farming, may largely be the product of the increasing price of grains when used in the production of fuel additives or substitutes. As such, it attests to the relevance of commodity prices as the main driver of efforts to find alternative fuels. As in the United States, Chinese industrial concerns hesitate to cultivate grains for animal feed that can alternatively serve as fuel sources. Grain sold as a fuel source pays much better. The effect is to cause farmers to select crops that they expect to yield the most substantial economic benefit.

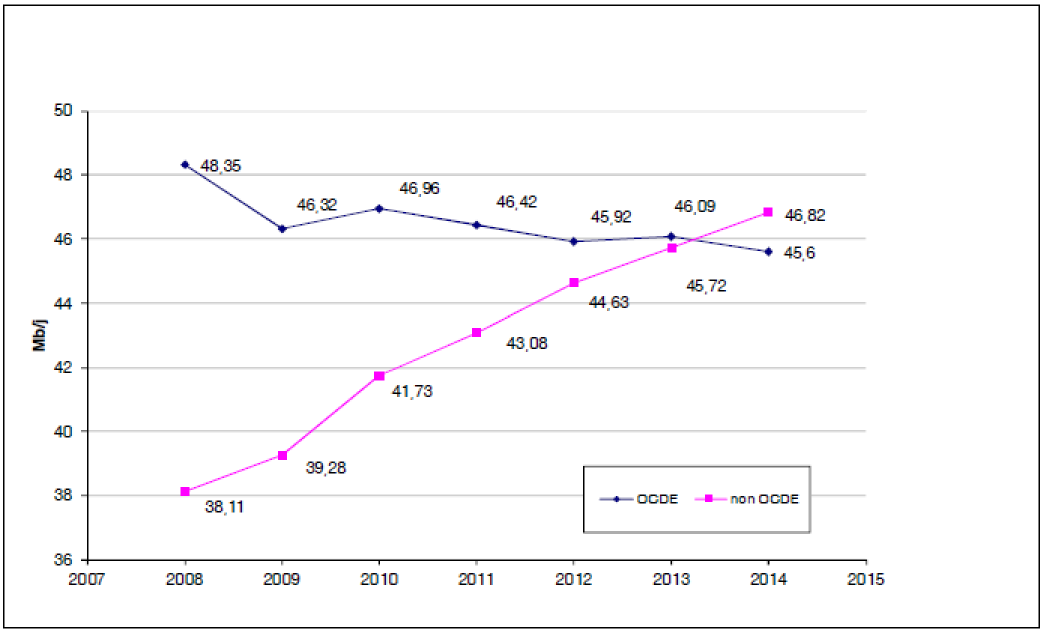
Finally, the rapid increase in the demand for energy from China and India can cause the poorer countries of the world to have to rely more intensely on biomass.[68] The result may be deforestation, desertification, and other extreme examples of the extinction of specific sources of fuel. Therefore, extreme distortions in global energy consumption can cause renewable fuels to become non-renewable. That is, while one normally expects to use biomass at the same rate as one plants new biomass, if this equation fails due to an unsustainable rate of biomass exploitation in a country, then what the country could previously call a renewable type of fuel has cease to fit into that category.

4.3 Social considerations

Social considerations mainly address consumers' choices. These choices define market forces at the individual level. They are greatly the product of consumer attitudes toward their own health and well-being in Shanghai. The key example of the social effect is in the example of what individuals in Shanghai did in response to the proliferation of natural-gas refuelling sites. An ancillary effect of Shanghai's effort to convert its taxis and public transportation to natural-gas power was the rise in LPG-powered motorbikes in the city.[15] One LPG-powered taxi consumes approximately the same amount of LPG as 70 motorbikes. By 2012, there were approximately 300,000 LPG-powered motorbikes on the streets of Shanghai.[15] This rise in motorbike sales appears to reflect a consumer-driven dynamic, by which the desire for clean-running vehicles is more palpable among those people who are actually wearing facemasks while maneuvering on the city's streets.

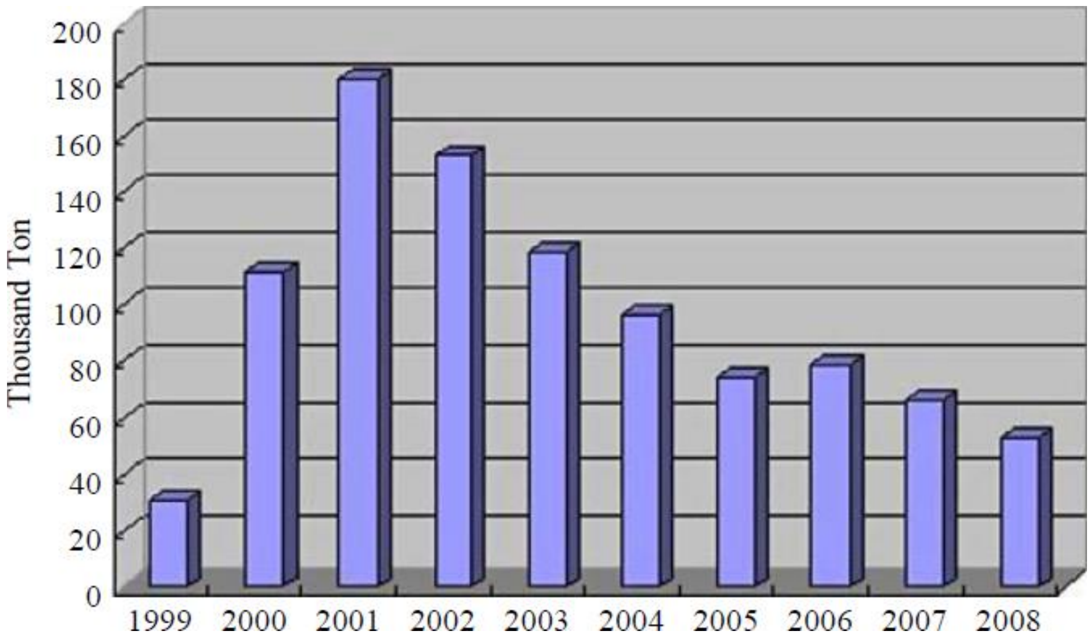
The projected ratio of the urban to rural population in China will exceed 50% by 2020.[78] Although the average urbanization across the world's 248 countries and territories will be approximately 62% at that time, the urbanization rate in China has far exceeded that of all other large countries. Indeed, social forces make a marked distinction between Shanghai and Paris. Figure 12 shows an aspect of this distinction in the form of differences in demand between OECD countries, which include France, and non-OECD countries, which include China. In this figure, a distinct attitude is starkly visible at the consumer level. Importantly, consumers in Shanghai are much more subject to the pull of individual economic choices on the matter of whether to purchase petrol-powered vehicles than are consumers in France, who can tolerate relatively severe restrictions in their choices by the government.

Figure 12. Changes in petroleum demand, OECD vs. non-OECD.[6]



To support CNG-powered bus fleets, CNG refuelling stations in Shanghai reached a maximum of four in 2004 and 2005, but declined to only two by 2008.[15] The two remaining stations thereafter continued to have trouble selling enough CNG to justify their existence. The needs of taxis to find convenient refuelling locations places greater pressure on the choice to adopt petrol-powered alternatives than would occur with normal passenger vehicles.[15] Therefore, the abundance of petrol stations, compared to LPG stations, has a more dramatic impact on taxi fleet compositions than would the same supply on regular passenger vehicles. Figure 13 shows the changing levels of sales of liquid petroleum gas in Shanghai.

Figure 13. Sales of liquid petroleum gas in Shanghai.[15]



Finally, a significant side effect of Shanghai's rapid growth is the city's attractiveness to poorer citizens from the countryside.[38] Migration from the countryside increases the concentration of low-income residents of Shanghai, who are less likely to consider purchasing alternative-fuel vehicles than wealthy residents are.

4.4 Technological considerations

Between Shanghai and France, the former has experimented most heavily with natural-gas alternatives to power city busses and taxis. The motivation behind this choice was the need to cut breathable pollutants, rather than to address the invisible, speculative effects of supposed greenhouse gasses.[49] By comparison, France announced in 2003 that it sought to cut its carbon emissions to one-fourth of 1990 levels by 2050.[67] This goal envisions a combination of technological shifting and emissions trapping, the latter entailing the use of carbon-targeting filters on fossil fuel and biomass exhaust structures.

By 2002, the number of CNG-powered Shanghai city busses had reached almost 400 in all.[15] Over time, however, as bus fleets replaced older vehicles with new purchases, falling petrol prices had brought about a reduction in this number, to only 140 by 2005. CNG-powered busses in Shanghai increased in number after their 2005 decline, to reach 281 by 2012.[15] Nevertheless, these still only account for approximately 1.6% of all busses on Shanghai's roads. Only about 2,000 Shanghai taxis continued to run on natural gas by 2008.[15] The Shanghai Municipal Government had abandoned its natural-gas conversion program in late 2006.

Meanwhile, China is also experimenting with specially created cities, which serve as an opportunity to test different ways of solving urban problems. Shanghai has created an experimental city in the form of Dongtan, designed to be the world's first completely self-sustainable community.[68] Although plans for completing the city's construction have lagged behind schedule, the goal is to provide residences for half a million inhabitants, with complete electrical and water self-sufficiency. The 2010 world exposition in Shanghai celebrated 21st-century achievements in green energy and alternative technologies.[28] Of special interest was the idea of sustainable cities, a concept that is very important in China today, given the enormous size of its burgeoning metropolitan areas.

The Tianjin eco-city, located 150 km from Beijing, is an experimental project of urban structuring based on the concept of complete energy self-sufficiency in urban living.[28] The project intends to be a working example of sustainable urban life, with a capacity of 350,000 residents by 2020. China currently has 15 experimental cities under construction or in use, ranging from Haidian District in Beijing to Pudong New Area in Shanghai.[41] Each city of this kind provides an opportunity to test one or more solutions to vehicle emissions or other effect of energy consumption in urban areas.

Overall, technological considerations are quite complex, as is visible in Figure 15. While the reader can easily compare the relative production of each different fuel source (CH = China; FR = France), the complexity of the full energy mix in a country impedes simple analysis. The experimental cities may provide sufficient control over these variables to draw reliable conclusions, but only after several years of effort.

4.5 Ecological considerations

Finally, the question of ecological considerations remains. In this domain, two opposite choices exist: (a) whether to focus on breathable pollutants; or (b) whether to focus on supposed greenhouse gasses. In fact, the former threat is quite real in Shanghai, while the latter is entirely speculative. Insofar as carbon-based output is a threat on both sides of the equation, there is no issue. However, the emphasis on carbon output, as opposed to sulphur dioxide, nitrogen compounds, and particulate matter, poses a threat of its own, namely, of deviating from the immediate threat.[76]

After essentially matching the United States in total carbon emissions in 2006, China has since surpassed the United States substantially, to become the world's leading producer of carbon emissions.[65] By comparison, France's carbon emissions production is unusually low on a *per capita* basis, due to the country's relatively heavy reliance on hydroelectric and nuclear sources. The largest national producers of CO_2 are currently the United States (20.3% of world emissions) and China (20.2%), based on 2006 figures.[65] These rates of CO_2 emissions are a direct function of the size of the respective economies in terms of purchasing power parity, as each country accounts for approximately 16% of GWP.

China's CO_2 emissions grew from being 28% less than those of the United States in 2000, to only 2% less in 2005, and finally to 8% more in 2006.[68] This trajectory is slightly exponential in nature and suggests the possibility of fully doubling US emissions by 2016. China's CO_2 emissions had surpassed those of the United States as early as 2006, despite having a much smaller economy.[68] This fact reflects how rapid growth in a large economy can exaggerate the amount of energy consumed by the country, compared to what would occur if the same large economy were experiencing growth at a more modest level, as in the case of the mature economies of the world. Figure 14 shows the relative amounts of CO_2 produced by carbon, fossil fuels, natural gas, electricity, heat pumps, and wood.

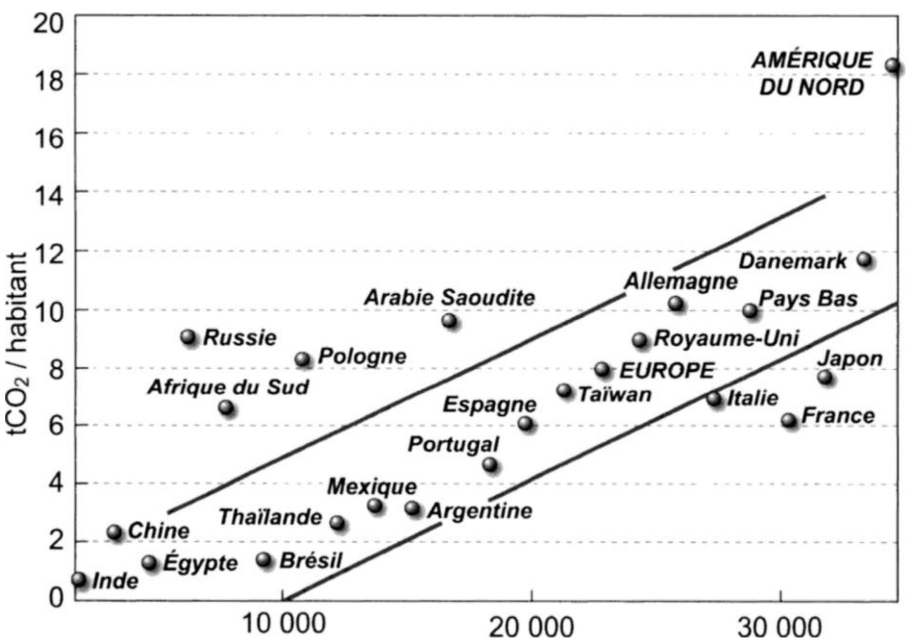
Figure 14: Carbon dioxide output from different sources of energy.[32]

Énergie	Charbon	Fioul	GN	Électricité	PAC	Bois[19]
Grammes de CO_2 par kWh produit	978	466[20]	242	180[21]	180/COP	6 à 14

China alone is responsible for the largest share of CO_2 emissions in the world.[68] In international negotiations, China has continued to seek an exception to any rule that might include a cap on carbon emissions. According to some commentators, developing countries, such as China and India, are much more vulnerable to the possible effects of climate change than are mature economies.[68] This proposition stems from the expectation that mature economies will be able to invest more heavily into technologies that succeed in minimizing those effects on their own populations.

Under the proposed principle of carbon credit transfer, countries may offset their own carbon emissions by investing in other countries' technologies for reducing greenhouse gasses.[19] However, neither China nor India has signed the associated protocol, so they will effectively bypass the need to compensate for their own overages.[30] Figure 15 shows the relative positions of various countries in terms of CO_2 emissions per inhabitant. It is clear from this chart, that the focus on CO_2 favours European countries.

Figure 15: CO_2 emissions and per capita GDP (PPP).[68]



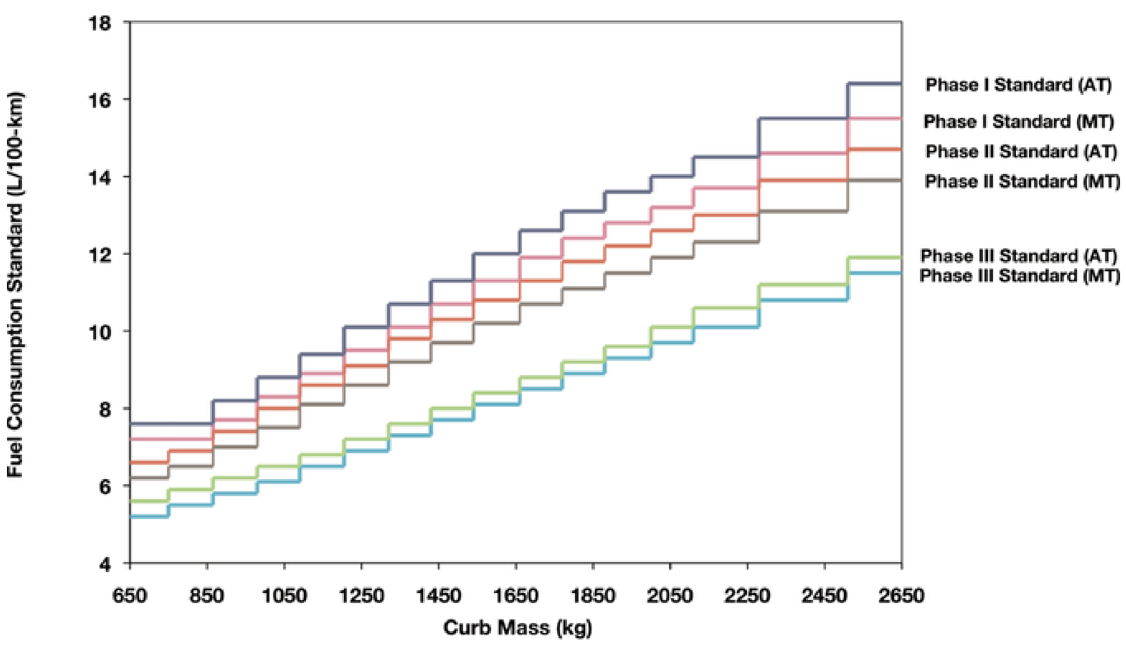
Vehicular CO_2 emissions are responsible for approximately 70% of all air pollution in Shanghai.[15] Although taxis and public transportation constitute only about 10% of vehicles on Shanghai's roads, they cause up to 50% of all air pollution in the city, due to their greater use. The priority for Shanghai is therefore clearly those forms of pollutants that threaten health in the immediate term, rather than those that some have speculated eventually to cause atmospheric conditions to change.

4.6 Legal and regulatory considerations

France has a far more robust policy-making apparatus than Shanghai does.[22] By comparison, Shanghai is strongly subject to market forces when attempting to influence the transition to alternative fuels among private citizens. While China is able to apply regulation on industry to approximately the same extent as European countries, the City of Shanghai has far less power.

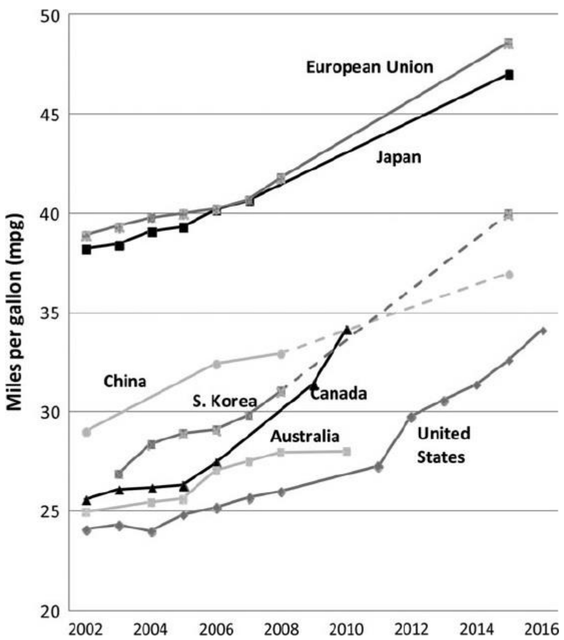
China first adopted fuel efficiency standards in 2004.[33] These standards addressed automotive manufacturing, rather than petroleum refinement. China's current fuel efficiency policy includes a target of 5.0 litres per 100 kilometres in fleet-based automotive performance by 2020.[33] The Chinese Government will also provide a tax credit for any company that adopts specified fuel-saving technology to complement manufacturing standards. China's fuel efficiency standards have functioned in phases.[33] Phase I began in 2005, Phase II in 2008, and Phase III, with a target of 9.11 litres per 100 kilometres, in 2012. Figure 16 depicts Chinese fuel efficiency standards by vehicle weight.

Figure 16. Chinese fuel efficiency standards by vehicle weight.[33]



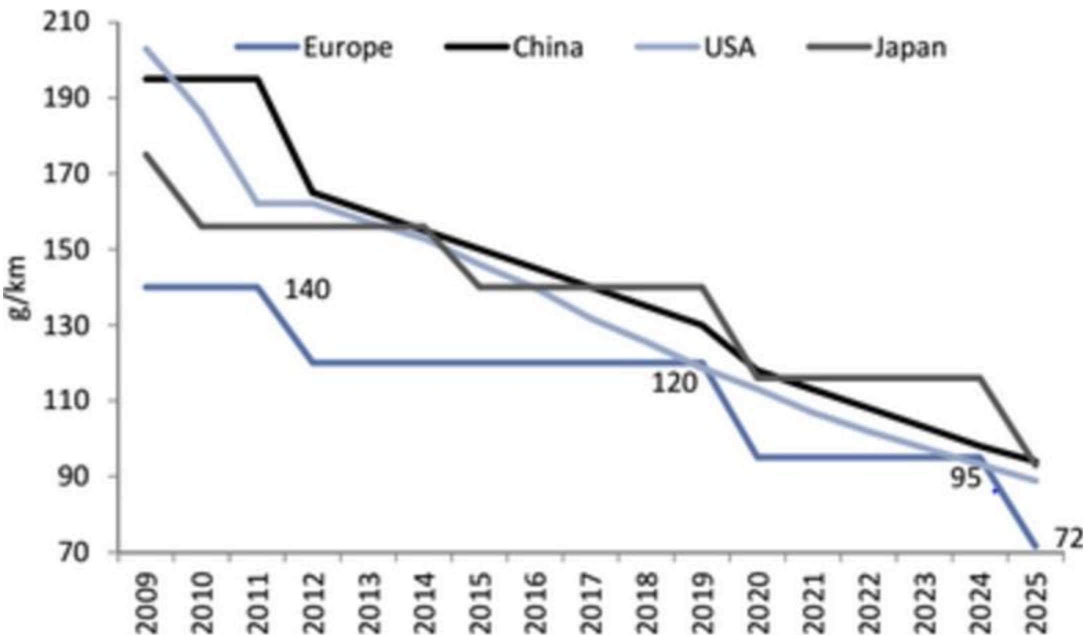
China’s primary policy for addressing air pollution has been the adoption of fuel efficiency standards with incentives to promote the purchase of increasingly fuel-efficient vehicles.[36] While the purchase of small vehicles aids in this objective, China’s consumers have been purchasing a greater share of large vehicles as the Chinese economy as continued to grow. After adjusting for the expected ratio of different vehicle classifications, China’s fuel efficiency standards averaged 14 kilometres per litre (kpl) in 2015, and 29 kpl by the year 2020.[39] In 2012, by comparison, the average vehicle efficiency in the United States was 10 kpl. Figure 17 diagrams the fuel efficiency standards of various countries.

Figure 17. Fuel economy standards for passenger vehicles.[4]



The Chinese Government announced in March 2011 its intention to pursue future growth with a view to decreasing per capita energy intensity.[2] An important part of the announcement included plans to dedicate 1.4% of GDP to building an infrastructure of new sources of energy. Government-sponsored rebates are a standard approach to inducing consumer purchases of vehicles that meet target qualities of fuel efficiency or fuel type.[35] However, such policies can disadvantage major automobile manufacturers and thereby cause indirect effects in the form of unemployment and cost of living. Figure 18 compares the planned emissions standards of various countries.

Figure 18. Planned emissions standards of major economies (g CO_2 per km).[42]



4.7 Motivation in Shanghai for alternative energy

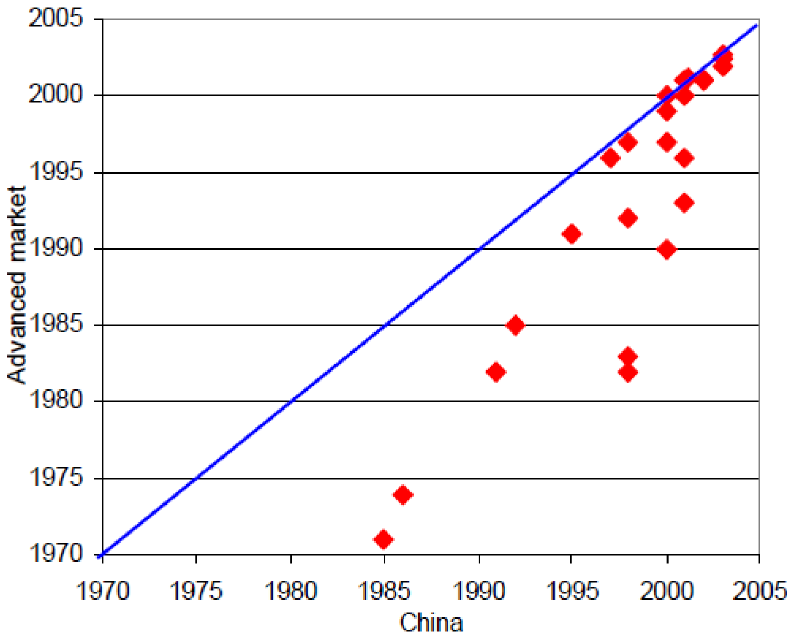
Every initiative that involves the development of a new energy infrastructure demands various considerations, including resource constraints, costs, and environmental impact.[65] However, these considerations affect different countries differently. The structural differences between mature economies and large, rapidly growing ones create strong distinctions in terms of the motivations behind the transition to alternative energy.[68] Among mature economies, which are mostly stable rather than rapidly growing, the impetus for pursuing alternative energy is part of a broader change in political attitudes, while the analogous motivation in China is much more practical.

The Chinese Government moved rapidly to adopt a progressive national energy policy at the start of the new millennium.[23] This policy included incentives to promote the adoption of environmentally friendly aspects in manufacturing, such as in the creation of eco-parks, which are business parks conceived with sustainability in mind. China's investments in overseas operations in the area of energy alternatives have a specific strategy in mind, namely, to exploit the potential for technological diffusion from such sources.[55] By focusing on technologies in the area of electricity-powered automobiles, China can thus acquire and develop its new technologies very rapidly.

Approximately 40% of China's expenditures toward economic development in recent years have had something to do with green energy.[20] This high number includes any industrial sector in which regulatory requirements include green-energy innovations of any kind. The efficiency with which fossil-fuel-based power plants produce electricity is the lowest of the available alternatives, producing waste at about 70% of total fossil fuels consumed in the process.[32] China and India continue to rely on fossil fuels, notably petroleum, as their main source of power plant operation.

Reinforcing this pragmatic motivation is the fact that China has been among countries recently hit by devastating floods, an effect attributed by many to the prospect of a warming climate.[32] Regardless of the cause, the challenge of the Chinese Government is to respond to an enormous range of possible catastrophes while trying to nurture a rapidly growing economy. Although the theory of global warming lacks direct empirical evidence, it has taken on great importance in international dialogues concerning the transition away from fossil fuels. Figure 19 shows a reflection of China's strategy, in terms of the visible convergence of Chinese productivity that of the major economies of the world.

Figure 19. Convergence of Chinese automotive production on global production.[61]



CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

History has shown that the rise of civilizations invariably produces some kind of fallout that represents a significant hazard to human beings.[23] During the Bronze Age, for example, each empire aggressively mined copper, tin, and other metals to support the new metallurgy, leaving behind exposed mineral remains in former mining sites, which were toxic to human beings. No civilization considered such benefits as warning signs, let alone physical restoration of the land. Rather, the common practice was simply to abandon an exhausted mine, implicitly inviting all potential visitors to beware of a phenomenon that they had never seen before.

In modern times, toxicity remains a problem, but often in a different form. Mining in various parts of the world continues to produce toxic land, such as the mercury that infests the soil in the Peruvian mountains after gold-mining efforts. Potentially toxic minerals continue to leach into groundwater, thereby making their way to human beings who draw it from wells. Animals may consume such poisons, which becomes an indirect threat to human hunters. However, a different kind of toxicity, in the form of pollution that threatens both visibility and breathability, is what characterizes rapidly growing economies in the 21st century. It is a natural consequence of the combination of rapid growth and the availability of mainly those kinds of fuels that produce harmful fumes.

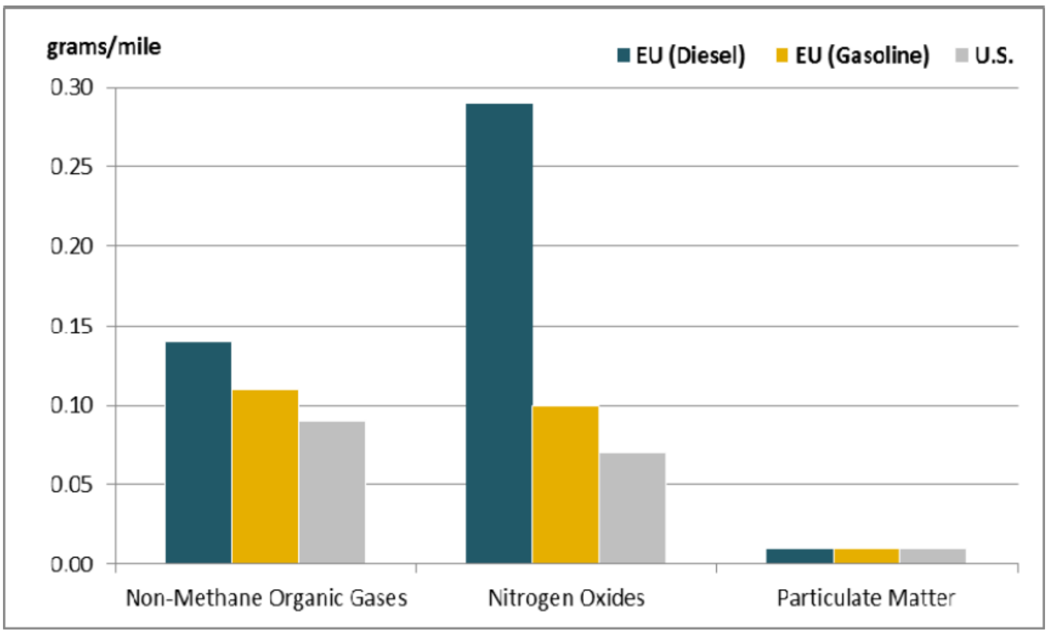
5.1 On globalization and global warming

Even if human societies succeeded in converting all electrical power generators into clean form, which seems possible despite the long effort that will be necessary to achieve such a state, locomotion throughout the world is independently a product of fossil fuels as well.[27] As the world economy has continued to grow, along with industrialization, the demand of national economies on world energy resources has grown precipitously. The greatest growth in demand has indeed been on fossil fuels, including coal, oil, and natural gas. Much progress has occurred in terms of building sources of wind power, hydraulic power, and solar power in various large economies, but these sources of power tend to be difficult to exploit fully. Solar and wind power require substantial terrain to draw a small amount of power, per square meter of land. Hydraulic power has its own limitations, such as the necessary to find exploitable currents, hence the use of rivers in most cases. Nuclear power is both efficient and clean, but nuclear power plants are very expensive to build.

Although globalization has received blame for ostensibly exacerbating the differences between wealthy and poor populations around the world, the opposite seems to have occurred in China and India.[68] In these cases, globalization has instead brought substantial revenues into the national economies, which have generally spread throughout the countries to benefit the population as a whole, rather than limited population sectors. Nevertheless, globalization has caused a shift in the world's most active centres of industrialization, from mature economies to the large, rapidly growing economies of China, India, Brazil, and Russia.[68] This shift has created separate economic blocs, which treat the issue of alternative energy differently.

The European fixation on global warming has caused its governments to tighten emissions standards more in carbon output than in those pollutants with more direct impact on breathability.[11] The policy deviation away from breathability issues and toward speculative matters regarding general atmospheric effects is visible in the other differences between the United States and Europe. Specifically, US emissions standards for nitrogen oxides and non-methane organic gasses are tighter than those of Europe are, at 0.04 and 0.06 grams per kilometre, compared to 0.06 and 0.07 grams per kilometre, respectively (Figure 20).[11] Unlike Europe, US standards apply equally oil refinement as to automotive manufacturing.

Figure 20. EU vs. US emissions standards for breathability-related pollutants.[11]



5.2 Prospects for Shanghai

Large, emergent cities like Shanghai arguably have more than one centre, so planners must often approach urban challenges in a way that is similar to the approach taken in heavily urbanized megalopolitan regions.[59] Economic analysis in China is easier when one analyses urban areas than when one analyses entire provinces.[58] This observation is due to the dominance of Chinese cities over Chinese provinces in terms of both the focal point of economic activity and the source of major decisions affecting each city and surrounding area. Meanwhile, the Chinese regulatory system has come to rely heavily on municipal governments in a sense analogous to how state governments once dominated regulatory policy in the United States.[60] Contrary to the assumptions associated with the view that Shanghai simply needs to apply some reasonable emissions standards, in fact, China currently imposes significantly more restrictive automotive emissions standards than does the United States, Canada, or the European Union.[20]

5.3 Reserving oil

The main goal in terms of energy security for both China and India is oil.[68] Thus, both countries seek to develop considerable oil reserves, to minimize the effects of future oil shocks on their economies. By implication, if these countries also benefit from sizable domestic oil reserves, they are refraining from exploiting them, as long as global oil prices remain low. Indeed, China has done little to confirm the size of its oil reserves for several years.[68] This fact has led to considerable uncertainty about the extent to which China needs to develop its petroleum industry. Meanwhile, China has evidenced an intention to save its own stockpiles of fossil fuels for the future.[1] In its discussions about energy transition with the United States, China has shown an inclination to accept whatever assistance the latter might be willing to offer toward supporting a global agenda of transitioning away from fossil fuels, as this stance provides China with the practical benefit of further bolstering its fossil fuel reserves.

China has accordingly demonstrated a conviction to pursue a long-term strategy of transitioning away from reliance on fossil fuels, rather than leaving immediate economic concerns to drive the decision.[1] This long-term strategy seems to anticipate and circumvent an eventual crisis in the 21st century in the supply of oil. To achieve this end, China intends to have considerable oil reserves on hand. The specifics of this policy are hard to discern, as there seems to be little transparency on this measure. Nevertheless, it is reasonable to surmise that China has sought to duplicate the strategic petroleum reserve of the United States, which the latter country built in the wake of the OPEC oil crisis of the 1970s. The US strategic petroleum reserve has since helped the country soften the shocks of various movements in global oil prices, including those that have been in reaction to cases of armed conflict in the Middle East.

China's insistence on building petroleum security has caused the country to seek to strengthen its political relations with selected oil exporters.[68] In this way, China's rapid growth has substantially altered the geopolitical structure. Low oil prices are a danger to the interests of a global agenda to transition energy reliance away from fossil fuels.[32] Nevertheless, global oil prices have dropped recently, in a way that casts doubt over how quickly they will recover, while both China and India have continued to increase their demand for oil. China's projected consumption of oil will therefore increase gradually to approximately 9 million barrels per day by 2030.[1] By comparison, according to the same projections, oil consumption in North American and Europe will decline to approximately 1 million barrels per day by the same time.

Among major countries, China has joined Japan, Brazil, and the United States in forgoing the signing of the global agreement of the International Agency for Renewable Energy, in Abu Dhabi in 2007.[32] This reticence is evidence, among all four countries, of serious hesitation over the possible loss of sovereignty over key energy-related decisions, as well as a reflection of the degree to which these countries consider this agreement to come with substantive rather than superficial requirements. Many observers doubt China's willingness to limit its use of carbon-based energy, except as prompted to do so by rising oil prices.[1] Consequently, high oil prices may be a necessary impetus for the transition to alternative sources of energy. China benefits from vast untapped resources in the form of tar sands and related types of unconventional sources of petroleum products.[65] The concern with these newly discovered sources is the fear of environmental damage that comes with their exploitation.

5.4 Market forces

Despite the most successful diplomatic overtures to promote a global agenda of research into alternative-fuel development, the most powerful impetus remains that of the price mechanism.[1] This fact is evident in the failure so far to harness the ingenuity of China and India fully in the same endeavour. To promote the use of electricity in place of combustible fossil fuels in automotive design, it is necessary to render electricity-based options attractive to the consumer market.[20] The lower reliability and inconveniences associated with electricity-powered automobiles in past years have constituted an important marketing hurdle to overcome in this regard.

The most effective means by which for one energy resource to supplant another is for the relative prices to alter, such as due to changing ratios of supply and demand over time.[12] When the reason for reducing demand for a particular source of energy is its cost to society in terms of damage, it is necessary to use policy, such as taxes or quotas, to achieve the same outcome as what would ordinarily occur through a change in supply and demand.

The experience of Shanghai shows that privately owned vehicle fleets would go back to petrol power if the cost-benefit analysis failed to justify continued use of alternative fuels.[15] Switching costs to return to petrol-powered vehicles are relatively low, because it is simply a matter of purchasing new vehicles for the fleet, to replace older ones. Ambiguity or uncertainty in the cost-benefit equation associated with a new versus an old source of energy will cause users to transition more slowly to the alternative.[17] A uniform, broadly publicized, and credible tariff system is therefore necessary to induce the voluntary adoption of the new energy source.

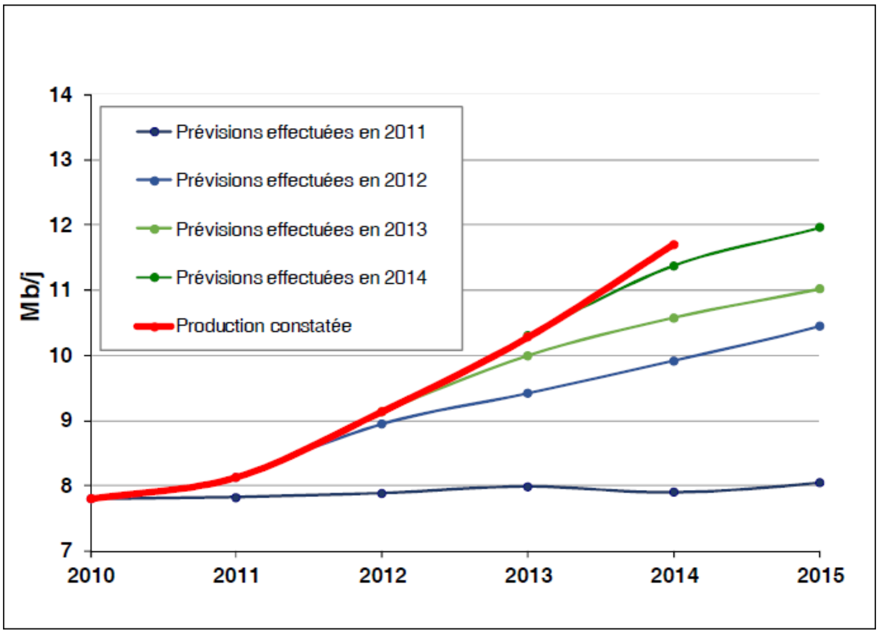
A combination of government rebates and fines, depending on the grade of a vehicle on a scale of grades from best to worst, may succeed in directing consumer behaviour toward the purchasing of alternative-energy vehicles through the price mechanism alone.[21] Moreover, transparency regarding subsidies and fees will influence purchases in advance of the enactment of the regulation, at least by a few months. A valid method for advancing the transition to new energy sources involves incentivizing long-term investment in targeted industries.[40] Effective incentives include freedom from taxation of long-term capital gains from investments in alternative-energy projects, in addition to tax credits under certain conditions.

Reliance on sheer supply and demand to determine the price of electricity from various alternative sources is insufficient for transitioning current sources to new sources with less negative impact on human society.[45] This inference is apparent in the fact that new technologies, which may produce systems capable of generating electricity at a lower cost per unit, nevertheless require sizable investments a priori, which the free market will fail to stimulate until the price of currently used energy sources becomes unsustainable for most individuals in the affected society.

5.5 Technological innovation

Economic studies often overlook the importance of human ingenuity in the face of large-scale change, such as that which has occurred in China over the past three decades.[34] As a case in point, some had predicted in the mid-1990s that China would lose cultivable space due to its rapid urban growth, when the opposite actually occurred.

Figure 21. Oil production in the United States, forecast vs. actual.[6]

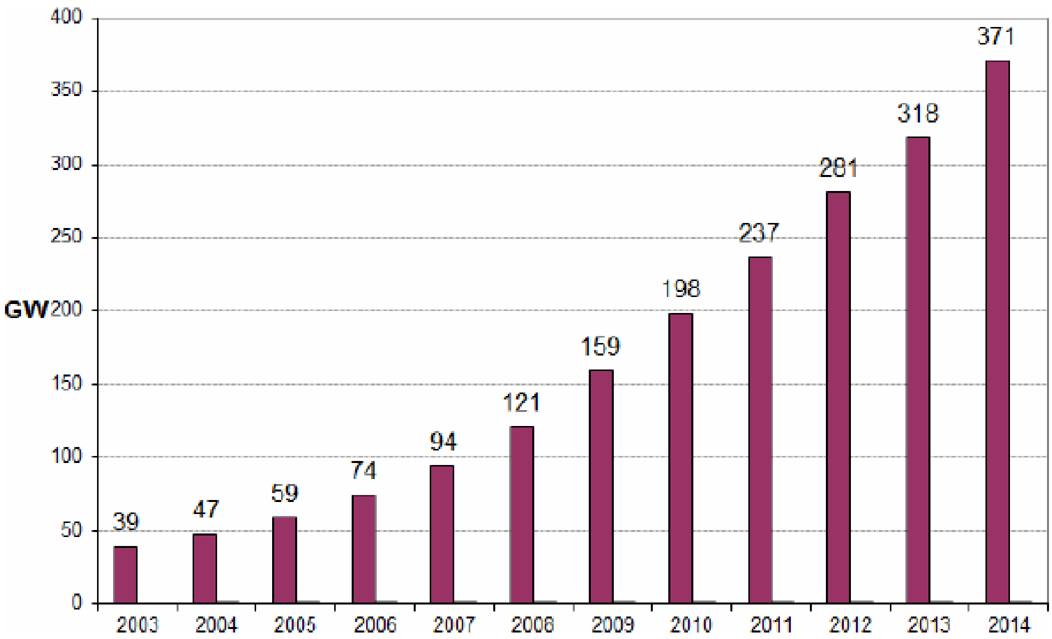


China has substantial potential in shale gas sources, which are amenable to the process of fracking invented recently in the United States.[22] Japan's need for natural gas, coupled with China's growing need for natural-gas imports, may therefore stimulate rapid development of this industry in China, further compromising global expectations for China to join the mature economies in cooperation over limiting carbon emissions from industry (even though the use of natural gas in vehicles helps in this regard).

By comparison, solar energy is barely profitable using current technology.[3] The likelihood of eventual profitability without government subsidy is greatest in locations such as Southern California or Southern Italy, where the price of electricity is already relatively high, while technological advances toward more efficient forms of converting solar energy into electricity are also present. Nevertheless, insofar as China is able to exploit large tracts of undisturbed wasteland in desert portions of the country, these areas may serve as important ancillary sources of energy, or at least provide supplemental energy to remote communities and thereby relieve the country of some of the burden of transporting energy sources long distances.

The growth of offshore wind-generated electrical-power plants is strongly a function of the length of each country's coastline.[31] This fact suggests that the feasibility or effectiveness of offshore wind-generated electricity depends very little on extraneous variables, other than simple access to coastal waters to build it. To demonstrate the increasing utility of wind power, Figure 22 provides a depiction of worldwide wind generation over the past several years.

Figure 22. Rise in wind-generated electricity over the years worldwide.[31]



Similarly, China's extensive coastline offers an abundant energy resource in the form of tidal energy.[47] The potential from the Chinese coastline for producing tidal energy, assuming 104 kW per offshore station, is as high as 224 million kW. China has yet to explore the full range of possible value that may be available in this resource. Meanwhile, technology for improving fuel efficiency in modern vehicles has taken several forms.[50] For example, designers have a choice between trying to reduce fuel consumption per unit of operational time and reducing fuel consumption over the course of an entire operational sequence, such as actual travel over a specified route.

5.6 Disposal issues and limitations

The development of electricity-powered vehicles will entail the production of a sizable amount of non-recyclable and potentially toxic components, especially durable batteries.[57] Consequently, advances in this area will require regulatory solutions to ensure the proper disposal of such components. Waste from nuclear-power plants becomes a reusable source of fuel up to a point, after which the potential for continued recycling of the same material ceases.[23] Disposing of the resulting radioactive waste remains a challenge, as the only solution that currently exists is perpetual storage. The standard remedy for potentially toxic waste products from manufactured items, such as batteries, is to require manufacturers to create a system to track disposal.[51] One method for this purpose is to provide a credit for the returned item upon the purchase of a replacement.

On the matter of the limited technological development of electricity-powered vehicles, however, Shanghai's inherent limitations may prove to be unique sources of value in a paradoxical way. That is, even if alternative-fuel vehicles are slower or require more refuelling points than petrol-powered vehicles, they may function effectively in dense urban areas, as opposed to major highways.[36] For this reason, urban vehicle choice policies may incorporate elements that are reasonably unavailable to consumers outside urban areas.

5.7 Policy clarity and enforcement

For the sake of adopting a coherent policy, it is necessary to clarity its rationale.[27] Confusion over whether energy usage policies seek to reduce breathable pollution, reduce global warming, or reduce dependency on foreign energy imports has led to inconsistent policy positions and undermined the effective use of free-market incentives to promote the desired energy transition. Some observers have argued that China's fuel efficiency regulations have been too complex to translate smoothly into a shift in market forces toward more fuel-efficient vehicles.[70] From this perspective, transparency and simplicity are important, especially if one extends policy to the voluntary front, as is necessary in Shanghai.

Meanwhile, voluntary agreements between governmental agencies and manufacturers are too subject to market forces to serve as reliable policy devices, but they do promote improvements in the desired direction.[53] As a case in point, voluntary agreements between the European Union and automotive manufacturers targeted 140 gCO_2/km in 2000, but achieved an average of 155 gCO_2/km by 2008. Whether for fuel efficiency or emissions, regulatory targets have virtually always been effective in securing stated objectives across countries, while voluntary targets have evidently only succeeded in Canada.[62] The reason for the Canadian exception is evidently a function of the relatively strong design of its own standards, which worked smoothly with manufacturers' competitiveness targets, unlike what has occurred in other countries.

5.8 Recommendations

To attract foreign direct investment (FDI) to stimulate the development of a complement of electricity-powered vehicles in Shanghai, the City Government should consider certain recommendations, based on the foregoing analysis. First, it is important to achieve clarity regarding the purpose of the City's plan to develop electricity-powered vehicles. The point is to divert the source of energy away from internal combustion and toward energy produced elsewhere in the country. The goal is to reduce air pollutants that threaten visibility and breathability, as opposed to attempting to alter prospective weather patterns in an unknown future. Accordingly, the first recommendation is as follows:

1. Shanghai should adopt an official policy position based on the goal to clean the city's air, without regard for arguments related to global warming.

Given the cost of purchasing new vehicles and the lower cost of refitting current vehicles to accommodate electrical power, the City should consider incentivizing both types, knowing that many consumers will opt for the hybrid choice. While hybrid vehicles will be only partially effective at mitigating pollution, they will nevertheless move the policy in the right direction, hence the next recommendation:

2. Shanghai should incentivize both electricity-only vehicles and hybrid vehicles.

The amount of the incentive must compete with oil prices. Given the City's inability to control oil prices, it will be necessary to secure substantial investments through other mechanisms. Shanghai should consider adopting a vehicle tax for vehicles located within provincial limits, to keep residents from simply moving their vehicles outside city limits as a remedy. The tax should rise in graduated fashion each year, from which hybrid vehicles will be half-exempt and purely electrical vehicles will be completely exempt, hence the next recommendation:

3. Shanghai should apply a tax to all petrol-powered vehicles located within the provincial limits, offering full exemption for electricity-powered vehicles and half-exemption for hybrid vehicles.

Regarding the city bus system and taxi services, the City should consider reintroducing the former natural-gas initiative, to take advantage of the pre-existing infrastructure of refuelling stations and the fact that most city busses and taxis are still operating under natural-gas power. The City should consider converting these vehicles to electricity power only after undertaking the full operation of promoting passenger traffic to transition to electricity power.

Finally, to secure FDI inflows to support this endeavour, the City should provide a captive audience to serve as a guarantee to companies that wish to consider setting up operations in the city to refit vehicles or to sell electricity-powered vehicles. The City should try to secure state funds to support subsidizing the purchase of electricity-powered vehicles, as this approach will serve to bolster sales in the city. The City should also issue certificates to subsidize hybrid conversions, hence the next two recommendations:

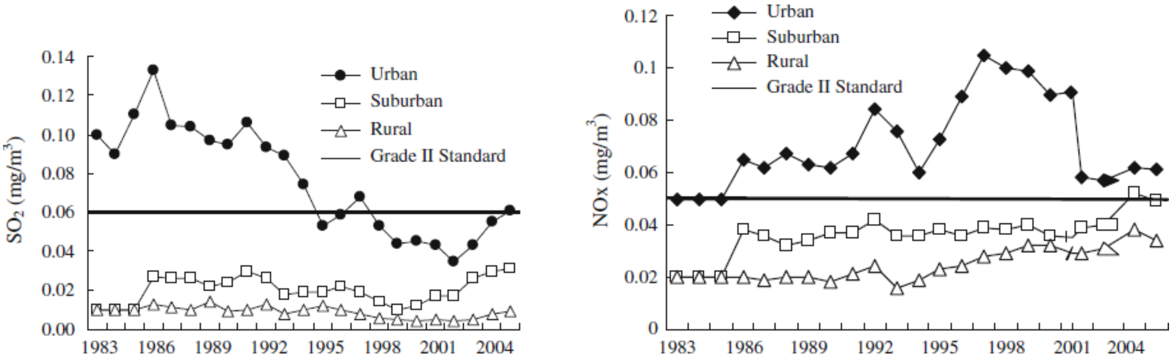
4. Shanghai should provide subsidies for companies that provide hybrid-refitting services in the city, along with discount certificates to city residents to take advantage of this service.

5. Shanghai should subsidize the sale of electricity-powered vehicles, to reduce their cost to a point of competitiveness with petrol-powered vehicles.

5.9 Concluding observations

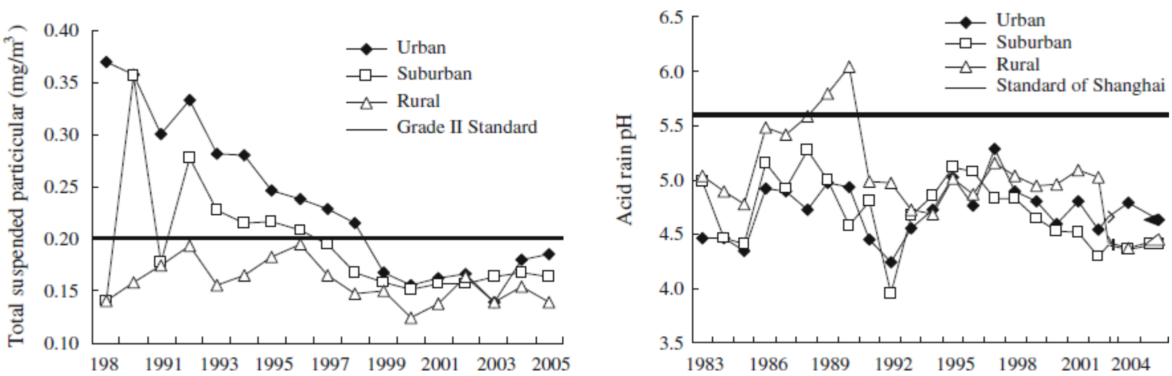
In retrospect, while considering all of the serious issues enumerated in this study, it is also important to observe that Shanghai has already made considerable progress on the path of reducing toxic pollutants. A substantial amount of additional work yet remains, but it would be fallacious to dismiss Shanghai as merely an example of deregulation in modern China. It is rather a good example of how difficult the task is. In fact, when measuring those pollution issues that matter to immediate concerns of visibility and breathability, Shanghai's situation is less bleak than the persistence of the haze might otherwise suggest. Shanghai's integrated air quality index is at a mean of 1.00, which is the same level as the national average for urban areas in China.[73] Suburban areas fare significantly better, with a mean of 0.81 in 2005, compared to rural areas, whose mean was 0.62 at the same time. Figure 23 provides a view of the progress made in Shanghai on two important measures of pollution.

Figure 23. Concentrations of SO_2 and NO_x pollution in China.[73]



On the matter of particulate matter and acid rain, Shanghai is similarly showing improvement over time.[77] In Figure 24, the regulated value established by the City of Shanghai is the horizontal line. As the figure shows, Shanghai is currently faring better than its regulated tolerance requires.

Figure 24. Concentrations of PM and acid rain pollution in Shanghai.[73]



Residents of Shanghai remark on the improvements in transportation that have occurred in recent years, including the efficiency of public transportation, the safety and quality of cycling and walking paths, and the opportunities to move about the city with less need to drive, hence greater ability to save money on fuel.[72] Thus, although Chinese cities have experienced a rise in pollution, they have also seen vast improvements in the management of city traffic.[48] In sum, Shanghai is already on the path to improving its conditions. However, it will be important for the city to maintain clarity in its goals as it continues in this direction.

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