WEC "Energy for Megacities" Study

Tokyo case study

Paula Restrepo Cadavid
Revised by Pierre-Noel Giraud

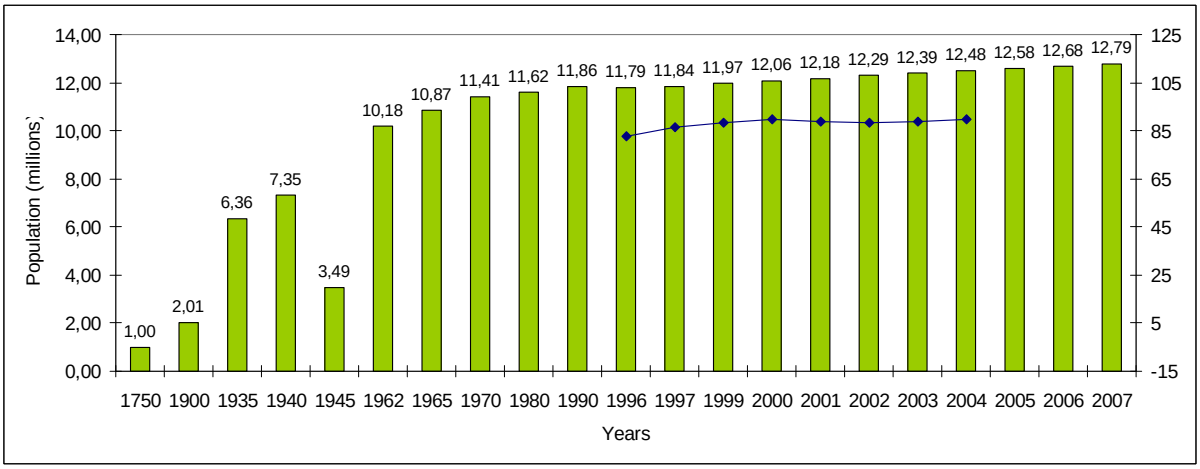
1.Data

Demographics, economics and city shape

The city of Tokyo comprises 23 special ward areas (8,7 millions inhabitants), the Tama area (4,1 millions) and the Islands (28.000). Tokyo, along with most of Chiba's, Kanagawa's and Saitama's prefectures makes part of the *Greater Tokyo Area.* While the city of Tokyo had an estimated population of 12.79 million in 2007, the *Greater Tokyo Area* population was estimated at 35,7.

In order to make a distinction between Tokyo and the *Greater Tokyo Area* we will refer to Tokyo as the city comprising 23 special ward areas, the Tama Area and the Islands. Most of the data presented comprises only Tokyo and in some cases only the 23 special wards[1]. Distinctions between will be done to avoid confusion.

Figure 1. Tokyo Population growth



Source: Metropolitan gov webpage

Even though Tokyo is referred as one of the biggest megacity in the world, declining fertility rates and modest migration make it one of the most slowly growing megacities in the world. While population growth rates have recovered slightly from the negative values observed in

[1] http://www.metro.tokyo.jp/ENGLISH/PROFILE/overview03.htm

the 90's, fertility rates continue to decline and are insufficient to assure population replacement. This makes parts of Japan's population shrinking trend.

Table 1. Population growth, density and fertility rates

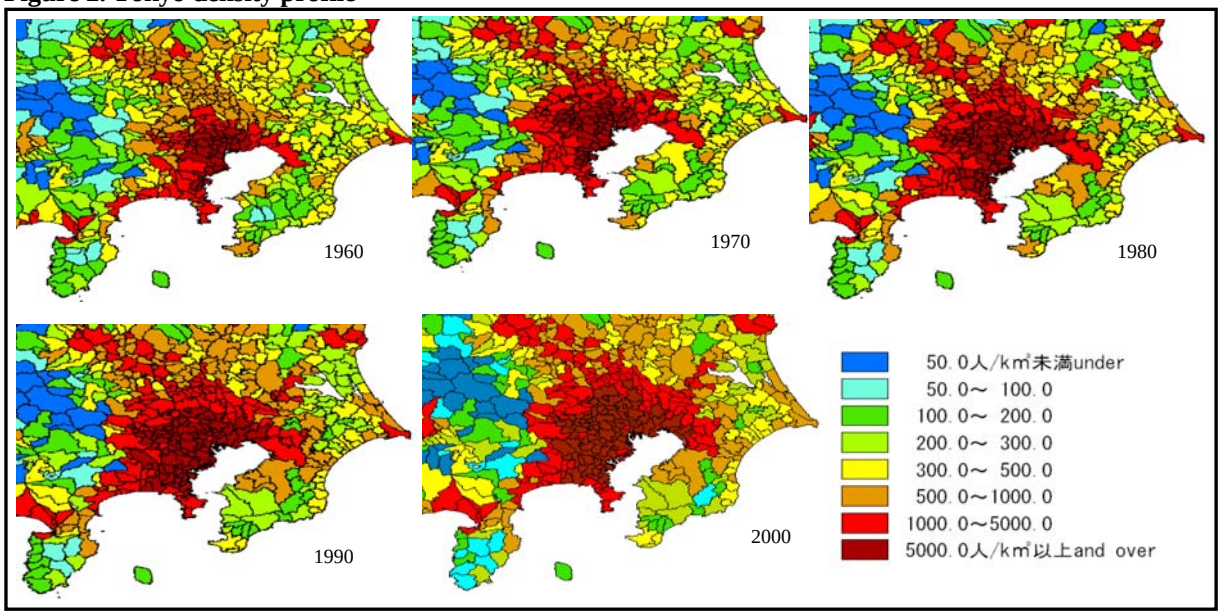
	1990	1995	2000	2005
Population growth (%/year)	-0,06	-0,19	0,68	0,76
Total fertility rate (%/year)	1,23	1,11	1,07	1,00
Density of inhabitable land (persons/km^2)	8 613	8 533	8 643	9 010

Source: Metropolitan government webpage

Tokyo compactness has its origins at the time of Edo, city that was totally dependent on walking and man pull/push carriage and where horse carriage where not commonly used. This human walking distance size restriction is at the core of Tokyo's density distribution and density, which has remained stable over the years at around 7000-8000 persons per square kilometer. Additionally, Japan's lack of natural resources and energy dependence central policies leaded Tokyo to become a mass urban transport oriented city which contributed to the conservation of its compact form. Figure 2 reveals Tokyo density distribution from the early 1960 until 2000. Contrary to other massive transport oriented cities, like Mexico DF, most of the school-work commuting is done by the metro while a miniscule share is done by buses.

As most cities in developed countries, Tokyo's economy is primarily based in tertiary industries that account for 77,4% of total employment (National Census, 2005) while the secondary sector only accounts for 18,7% and the primary sector for around 0,4%. GDP of Tokyo accounts for about 18% of Japan's GDP while concentrating around 10% of Japan's total population.

Figure 2. Tokyo density profile



Source: WEC Tokyo

Energy and GHG emissions

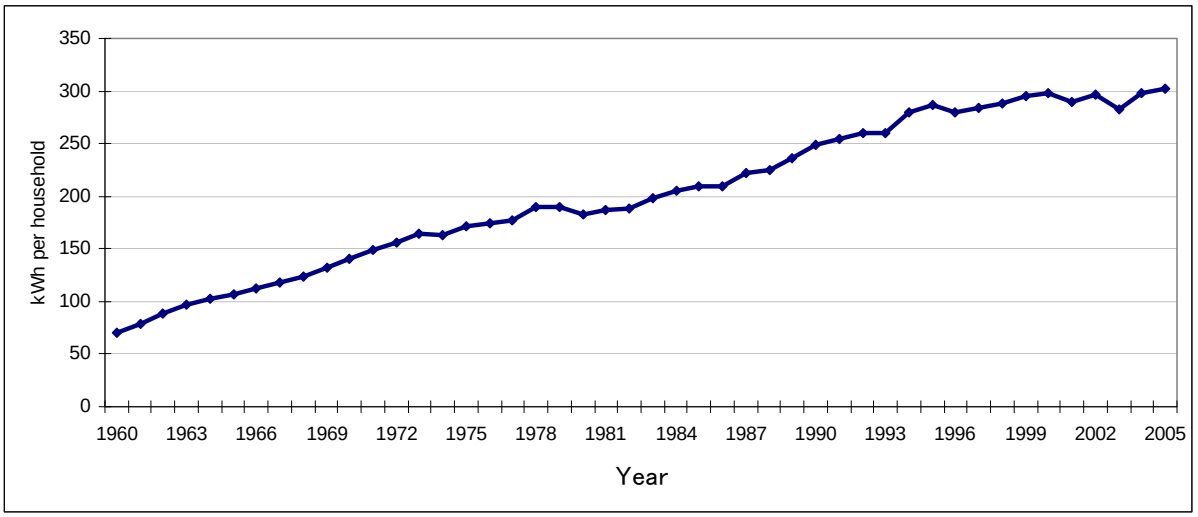
Energy consumption

Households

According to Dhakal and Kaneko (2009), per capita energy consumption in urban areas in Japan is lower than that of non-urban areas. Historically, while there seems to be a continuous increase in residential energy requirements since the early 50's[2], the energy intensity (GJ/m^2) of this sector has been reduced since the early 90's[3]. This could be explained by the slowing of household income and the saturation of household appliances. Tokyo, when compared to other megacities of its type has a very small energy consumption per capita (69MJ/p) against 178MJ/p in New York and 85MJ/p in London.

Most (67%) of the energy needs of the average household in Tokyo are concentrated in four categories: air conditioner (25.5%), refrigerator (16.1%), lighting (16,1%) and television (9,9%)[4]. Air heating doesn't represent a big share of household's energy requirements since Japanese families don't usually heat the whole house in cold seasons. This shows the importance of behavior in energy consumption. In this manner, reducing energy consumption of the average household in Tokyo has to comprise two different policies (on demand side): energy efficiency appliances and consumption behavior.

Figure 3. Electricity consumption per household in Tokyo



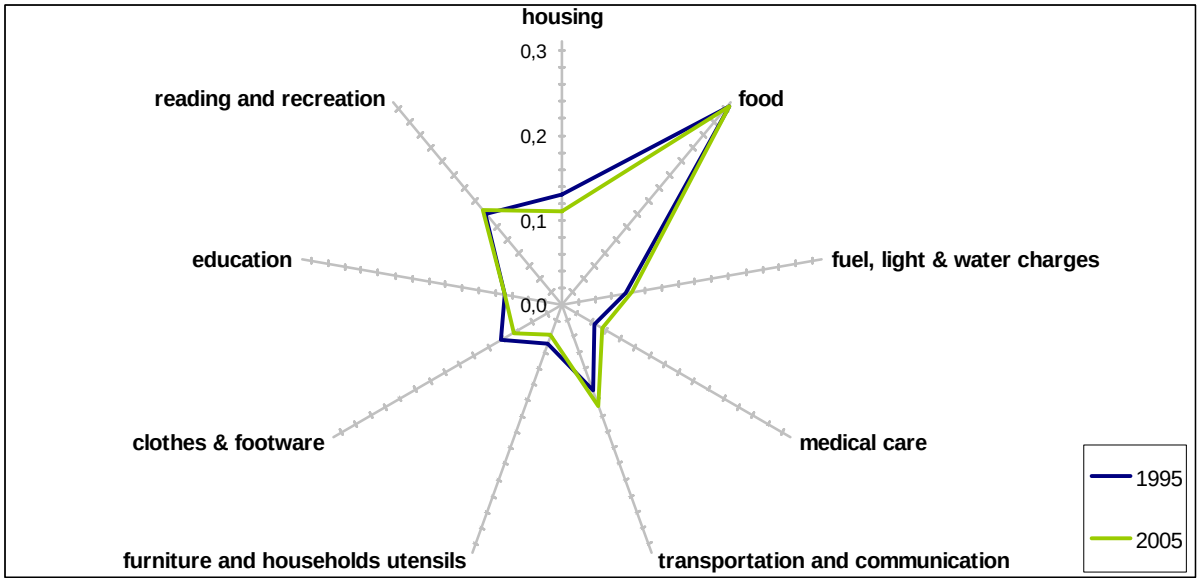
Source: TEPCO ILLUSTRATED 2008[5]

In the case of the city of Tokyo energy expenses are relatively small when compared to the rest of expenses and there has been little change in the past decade. Additionally, energy

[2] passing from 49Kwh in 1951 to 297 in 2007
[3] TEPCO Illustrated 2008
[4] TEPCO Illustrated 2008
[5] While they are other companies apart from TEPCO that supply electricity to Tokyo Metropolitan Area, most of the electricity is supplied by TEPCO.

expenditure pattern in Tokyo is equivalent to Japan's typical household expenditure distribution. No evidence of energy poverty was visible from available data.

Figure 4. Expenditure distribution of the average household in Tokyo

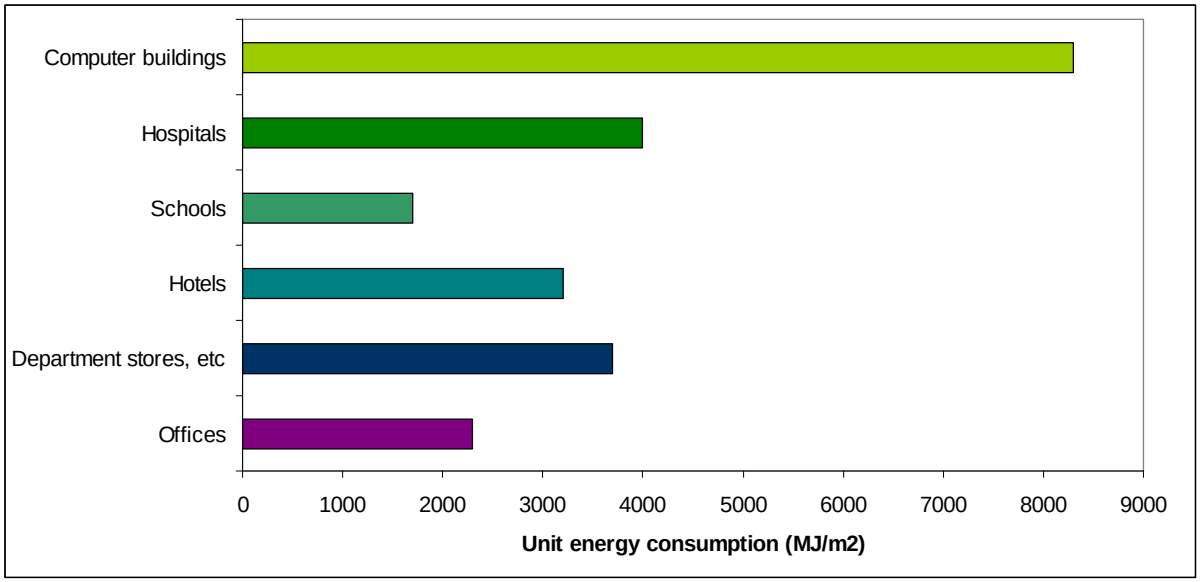


Source: adapted from TMG general statistics, 2007

Buildings

Figure 4 shows energy intensity for different types of service buildings. One can see clearly how computer buildings double and even triple the energy requirements of other type of uses. The former combined with the fact that Tokyo is a tertiary sector based economy evidences the importance of making climate change and energy policies oriented towards the business sector. Furthermore, the recent evolution of total energy consumption by sector shows an increase relative importance of the business sector.

Figure 5. Energy consumption per unity of surface

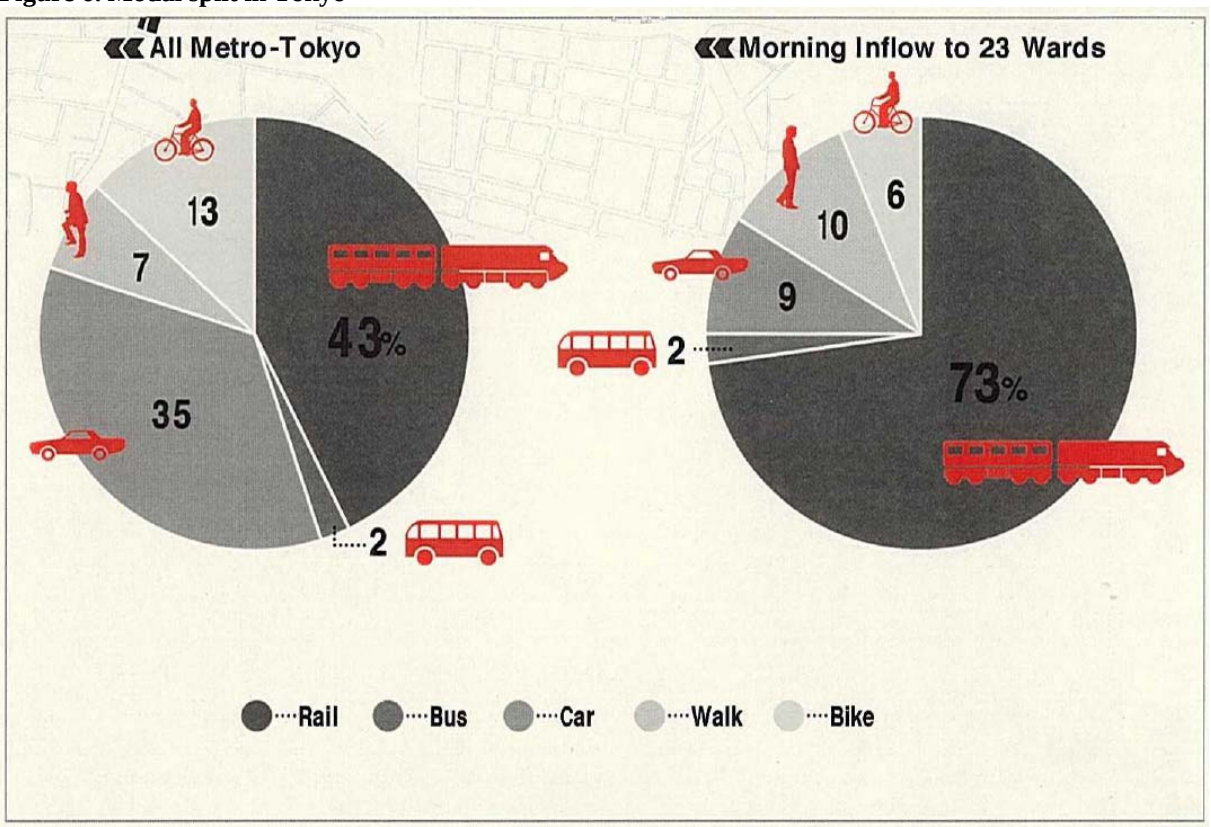


Source: Tokyo Metropolitan Government Environmental White Paper (2006)

Transport

Tokyo high vehicle ownership rates (308 vehicles/ 1000 persons) might give the wrong impression of transportation choices of this megacity. In reality, although there are many vehicle owners, most of the population (75%) uses public transportation for work-school commuting and only 6% use only their personal vehicle to commute. Bicycle and walking also take a big share of the modal split and awkwardly the share of bus transportation is quite small.

Figure 6. Modal split in Tokyo

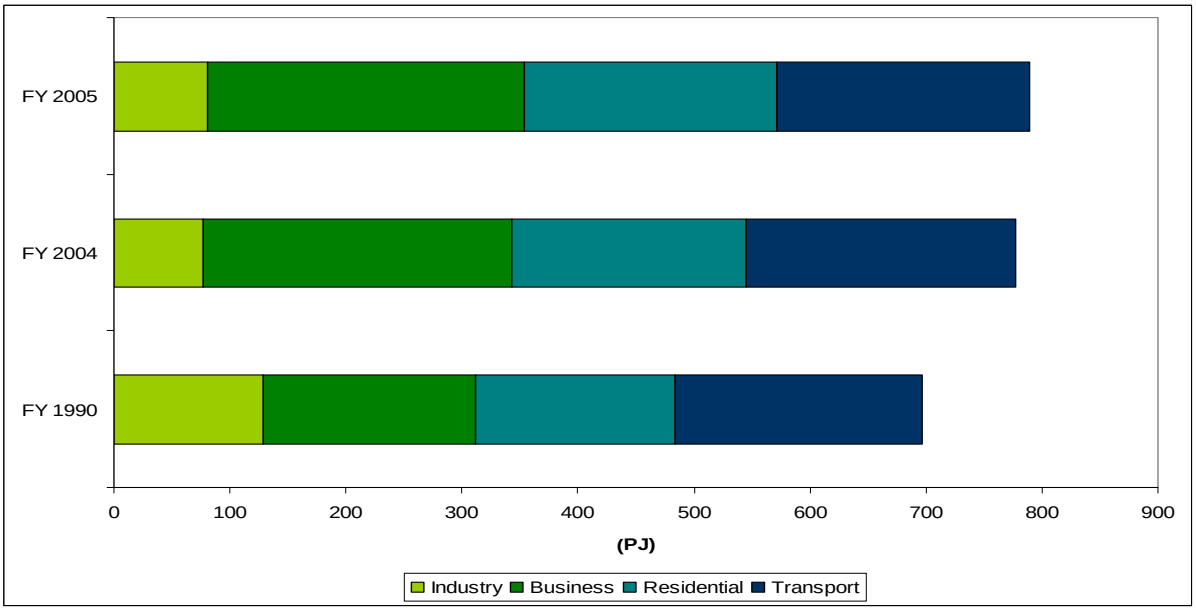


Source: Person trip survey, 1998

All sectors

In absolute terms the energy needs for the transport sector have increased considerably in the past two decades. This could be explained, in part, by the enlarged share of big engine cars. For instance, the share of car with 2000 cc or more in Japan increased from 6% in 1990 to 27,5% in 1997. The extension of this trend is however doubtful in the new era of high oil prices and climate change policies. In relative terms, the share of energy requirements of the transport sector has been reduced from around 35% in 1990 to 28% in 2005. For the same period the business sector has increased its share from 26 to 35%, the industrial sector's share has been reduced from 19% to 10% and the residential sector has passed from 25% to 27% (see figure 7).

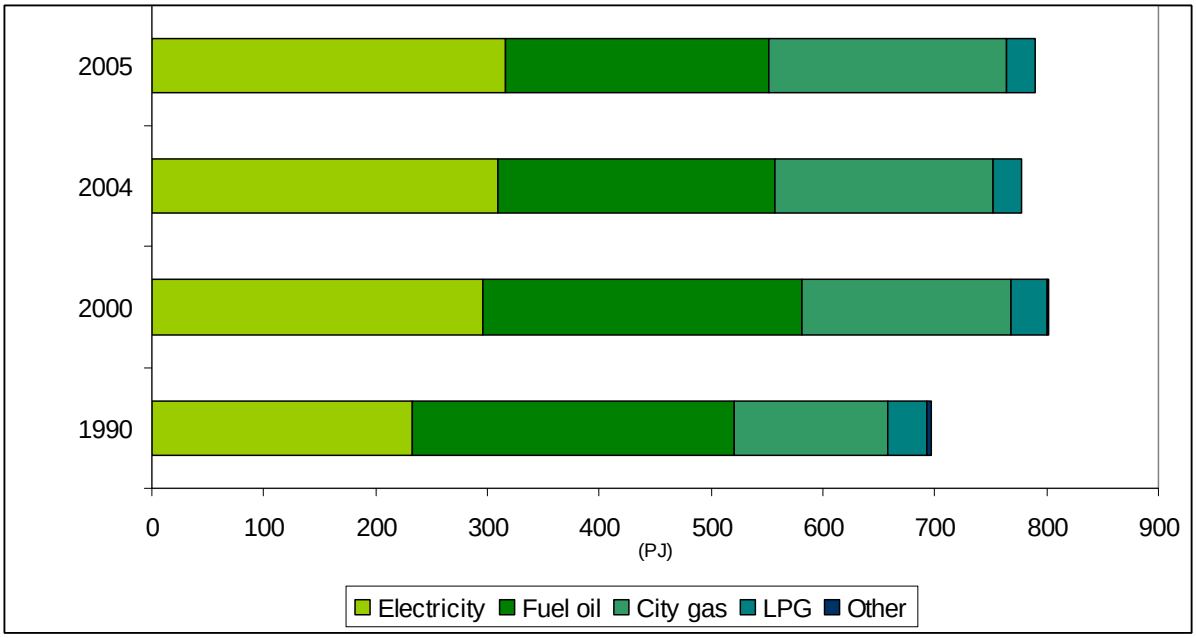
Figure 7. Changes in total energy consumption by sectors (1990- 2005): Tokyo Metropolis



Source : http://www.kankyo.metro.tokyo.jp/kouhou/english/master-plan/pdf/part2-chapter1-section1-1~2.pdf

This transition between energy needs in different sectors can also be evidenced in Figure 8, showing the total energy mix (by energy source) of the city. The proportion of energy needs supported on electricity has grown considerably (from 33% in 1995 to 40% in 2005) while the proportion of fuel oil has been reduced from 41% in 1995 to 30%:

Figure 8. Changes in total energy consumption by source (1990- 2005): Tokyo Metropolis



Source: http://www.kankyo.metro.tokyo.jp/kouhou/english/master-plan/pdf/part2-chapter1-section1-1~2.pdf

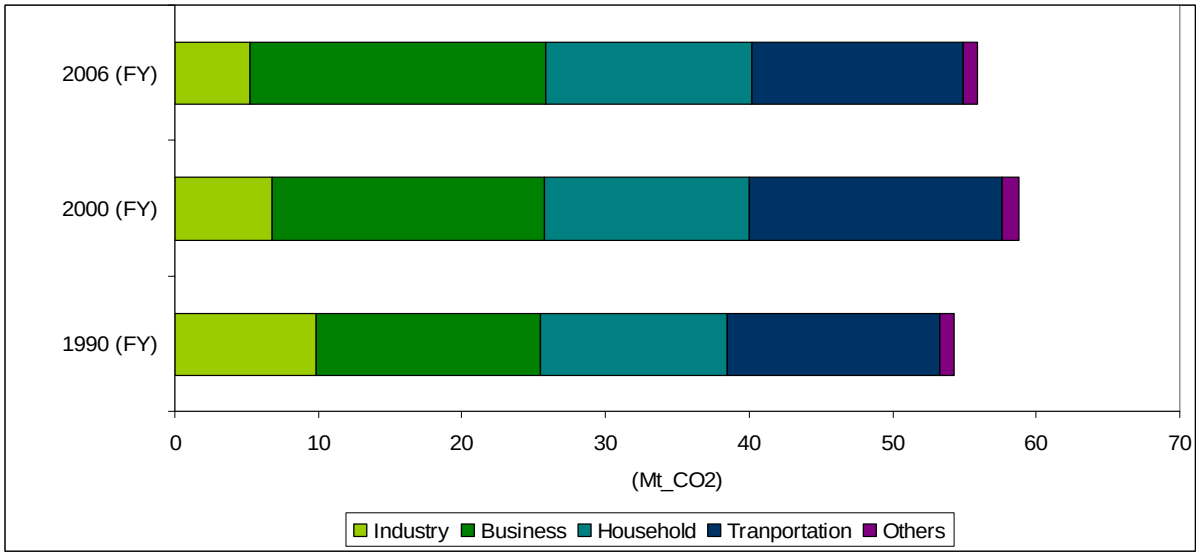
GHG Emissions

A general comparison between OCED countries, major non-OCDE countries and cities in East Asia shows, that in terms of CO_2 per unit and CO_2 per capita, the overall performance of Japanese cities is better. The performance of Tokyo alone is outstanding (Dhakal and

Kaneko, 2009). Tokyo compactness and the predominance of public transportation make it not only an energy efficient city but a relatively low carbon emission city.

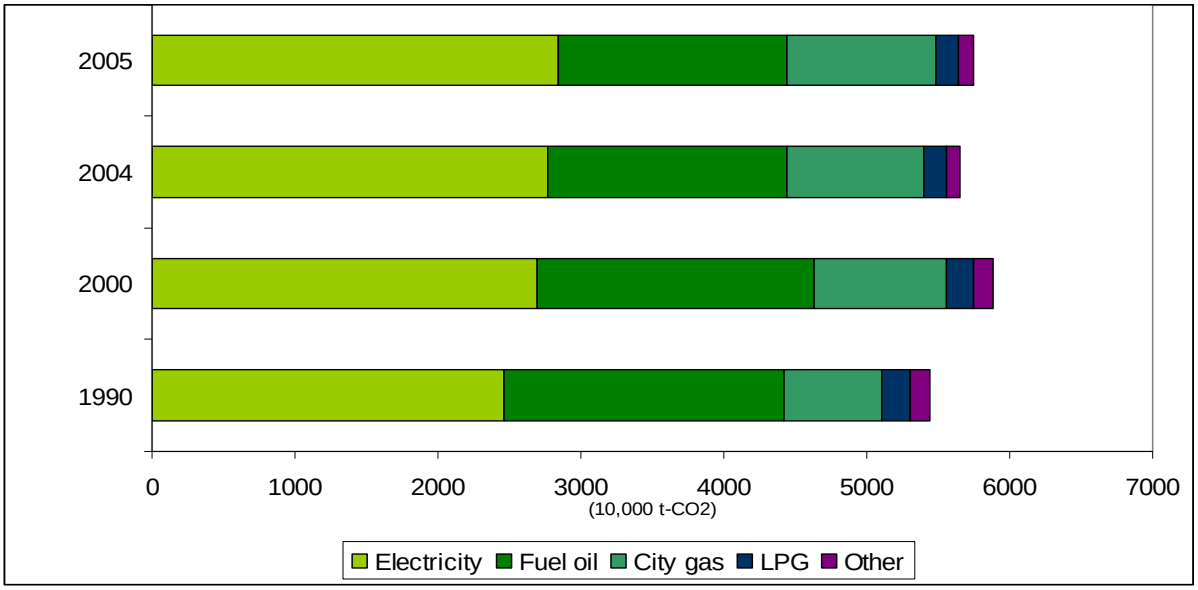
A comparison of GHG emissions comparison between sectors signals the increased relevance of the business sector which rose around 57% in the 1990-2003 period. Increased floor area of office buildings and the expansion of office automation might be at the core of this trend[6]. While overall emissions were reduced slightly between 2000 and 2006, the share of the business sector continued to grow and the share of the industrial sector continued to shrink. Residential sector remained about the same. When looking at emissions by energy source it is evident that a greening of the energy mix used to generate electricity is needed to achieve a considerable evolution towards a low carbon city.

Figure 9. Emissions and emission growth by sector



Source: Tokyo Cap and Trade Program TMG (Tokyo Worskshop 2009)

Figure 10. Emissions and emission growth by energy source

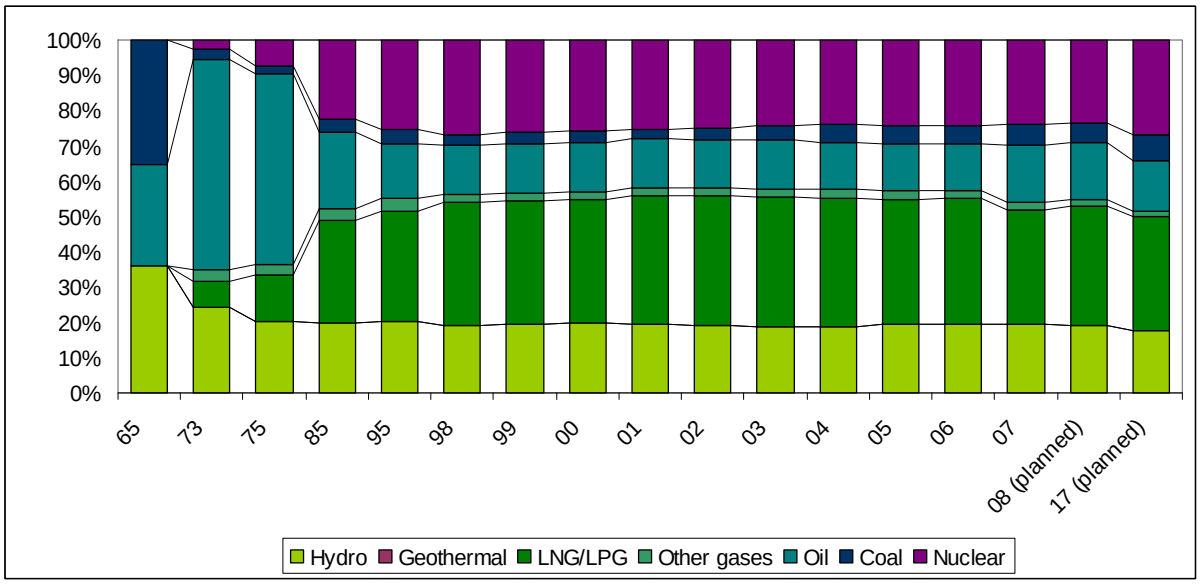


Source: http://www.kankyo.metro.tokyo.jp/kouhou/english/master-plan/pdf/part2-chapter1-section1-1~2.pdf

[6] Prevention of Urban and Global Warming, TMG

On the supply side, primary energy sources mix for electricity generation for the city of Tokyo has suffered serious changes since late 60's. The share of nuclear power has been increased and the share of oil and coal has been reduced and replaced by gas. In addition, projections for the year 2017 show a further decarbonisation of energy sources.

Figure 11. Generation capacity by energy source (TEPCO including purchased power)



Source: TEPCO Illustrated 2008

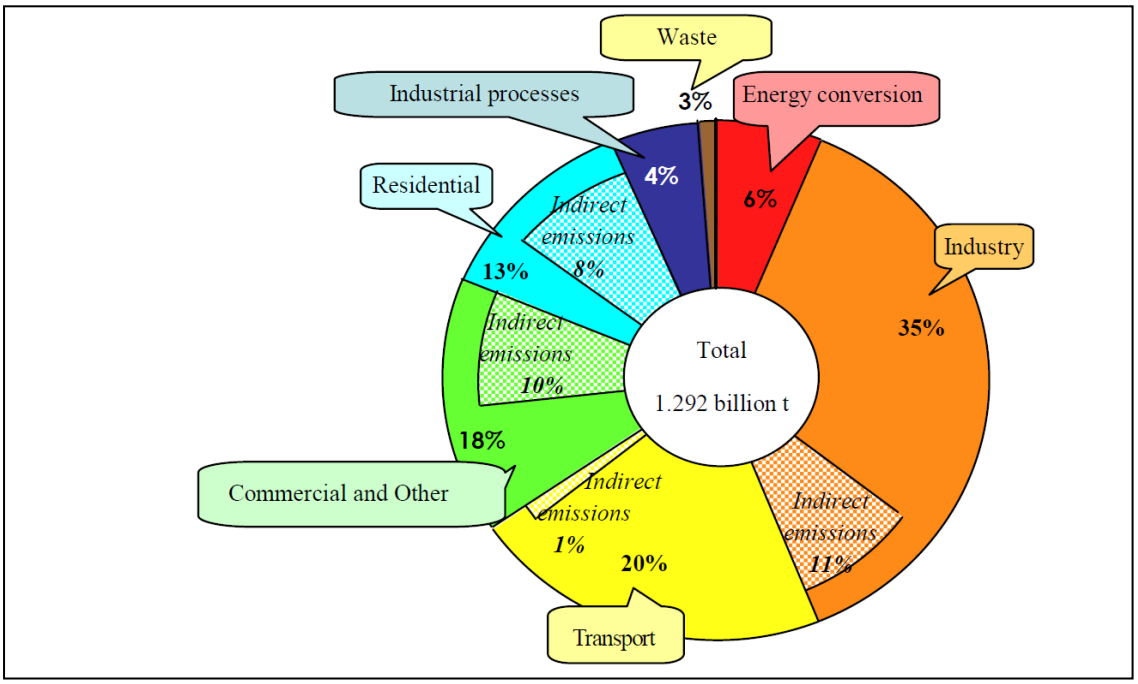
One additional element that must be taken into account when analyzing emissions and energy use in the city of Tokyo is the urban heat island effect. This is one of the down factors of being a compact city. Even though it is difficult (or impossible) to asses which share of the increase temperature is due to climate change and which share is due to the heat island effect, both phenomenon's together have had serious consequences. In the past century (1908-2008) temperatures inside the city have risen by 3.2 °C. Urban heat island effect generates a vicious circle: higher temperatures create a bigger need of air conditioning which reinforces the urban heat island phenomena.

2. Policies

National energy plans and policies

Japan's Carbon Dioxide distribution of emissions differs from Tokyo's distribution. For instance, the highest shares of emissions in the whole country correspond to the industrial sector followed by the transport sector. This mismatch between shares of emissions might be an additional problem when trying to pass from national to local energy and climate change policies. While the government might concentrate its efforts on the industry sector, this type of policy doesn't make sense at Tokyo local scale.

Figure 12. Japan's Carbon Dioxide emissions by sector



Source: Kyoto Protocol Achievement Plan (Revised March 2008), Ministry of Environment

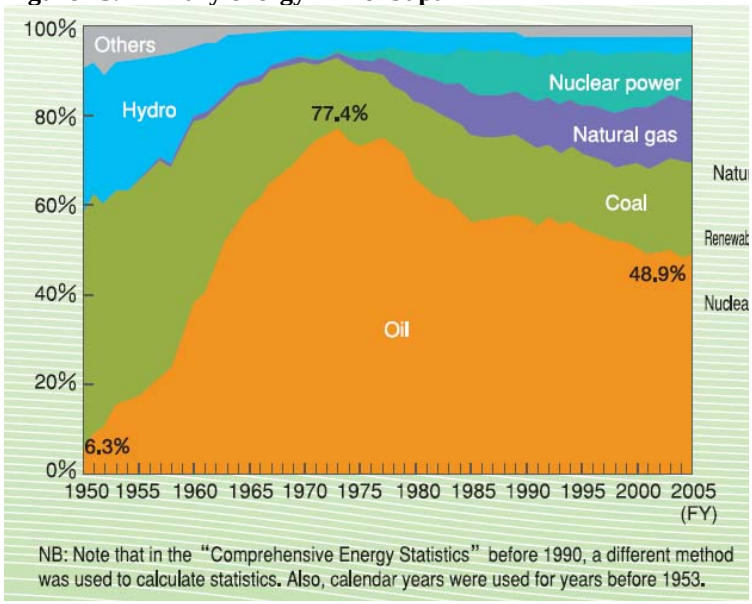
In terms of climate change Japan has set a series of short term policies based on the Kyoto protocol objectives and long term policies for the post-Kyoto period. By the year 2012, Japan is expected to reduce its GHG emission by 6% from the 1990 level according to its target set by the Kyoto Protocol. However, by fiscal year 2006 CO2 emissions had already augmented by 6,2% against base year. By the year 2007 GHG emissions had gone up by 9% against base year partly due to the suspension of operation of the Kashiwasaki-Kariwa nuclear plant that evidence some security concerns following the Niigata Chuetsu earthquake in July 2007. The former make's it particularly difficult for the country to achieve its current reduction targets and fulfill its future objectives, set by the new prime minister to achieve a diminution by half from the present level by 2050[7]. Furthermore, Japan's energy mix continues to be highly dependent on fossil fuels, specially oil and coal (
Figure 13) and Japan is the according to statistics the least energy intensity country in the world (Primary energy/GDP)[8].

On the demand side, Japan has introduced a series of legislation to introduce energy efficiency in each sector of the economy. The Energy Conservation Act (Act on the Rational Use of Energy), promoted at the national level, requires large factories and other business establishments to conduct systematic voluntary energy management by obligating them to periodically report on the status of their energy use and formulate and submit medium-term plans for achieving energy conservation targets. In addition, it obligates the submission of the notification of energy conservation measures on the occasion of new construction, expansion, renovation and large-scale repair of buildings larger than a certain size. Under the same law, the energy efficiency standards for home electric appliances and vehicles

[7] Others : Fukuda Vision (2008) : don't really know its base, and Cool Earth 50
[8] « Energy in Japan » Agency for Natural Resources and Energy Ministry of Economy, Trade and Industry

have been set based on the top-runner system, which requires standards to be set at the levels of the most energy-efficient products that are available at the time, and manufacturers are obligated to comply with these standards.

Figure 13. Primary energy mix of Japan



Source: http://www.enecho.meti.go.jp/topics/energy-in-japan/english2008.pdf « Energy in Japan » Agency for Natural Resources and Energy Ministry of Economy, Trade and Industry

On the supply side, Japan's government has introduced legislation to increase the use of non fossil energies. The New Energy Usage Act (Act on Special Measures concerning New Energy Use by Electric Utilities) is meant to encourage the use of new energy in order to secure stable and appropriate supply of energy by obligating electric power companies to use electricity generated by new energy in a proportion exceeding the prescribed level according to the amount of their electricity sales. A subsidy scheme has been introduced in order to expand solar photovoltaic (PV) power for the installation of household-use solar PV power generation systems and a new system of purchasing surplus electricity generated by such systems under which the purchase price has been roughly doubled from the previous level has been launched. It is also considering the specifics of a system for the purchase of all electricity generated by not only solar PV power but also various other types of renewable energy.

Since having an accurate emissions inventory and processes to control targets is essential, the national government has also introduced the Act concerning the Promotion of the Measures to Cope with Global Warming, in which business operators that emit a large amount of greenhouse gas (GHG) are obligated to calculate and report their own emission amount to the national government. This Act also concerns the formulation of a plan for achieve targets under the Kyoto Protocol and must specify the basic matters related to measures that should be taken by the national government, local governments, business operators and citizens to reduce GHG emissions.

Figure 14 shows the instruments and sectors used for policy making in Japan during the past 34 years. For instance, renewable energy policies are mostly implemented through

subsidies/incentives and backed up by research and development financing. On the other side, energy efficiency policies are mostly based in education and outreach or regulatory instruments.

Figure 14. Climate change, renewable energy and energy efficiency policies in Japan (Instruments and sectors)

Source: adapted by author from IEA database (2009)

Local plans and policies

As Japan, Tokyo has established its own targets of CO_2 emission reduction and energy associated policies. *Tokyo Climate Change Strategy* proposes a reduction of 25% of the CO_2

emissions by 2020 from the 2000 level which leads to about 20% when compared to 1990 level.

Tokyo Climate Change Strategy is divided into five initiatives and main activities for climate change mitigation. Turning Tokyo into a low carbon society is base on two principles: reducing energy consumption by implementing **energy conservation measures** and using **passive energy** and strive to **use renewable energies** and **unutilized energies** in a positive manner. The following box presents a brief description of the policy package for Tokyo.

Box 1. Tokyo Climate Change Strategy initiatives

Initiative I: promote private enterprises' efforts to achieve CO_2 reductions

- Cap and Trade System: big business
- Environmental Collateralize Bond Obligation (CBO) : small business
- Environmental Investment and Loan options
- Green purchasing program

Initiative II: reduction in households – light and fuel expenses

- Incandescent lamps elimination campaign
- Passive energy (light, heat & wind)
- Energy saving performance of houses
- Renewable energy & energy saving equipment

Initiative III: reductions in the urban development

- World Highest Energy conservation specifications for buildings: Tokyo Metropolitan Government facilities
- New buildings to have energy conservation performance
- Energy conservation performance certificate program
- Effective utilisation of energy and use of renewable in local areas

Initiative IV: vehicle traffic

- Fuel efficient vehicles and widespread diffusion of hybrid cars
- Green vehicle fuel conducive
- Voluntary activities : Eco-drive campaign
- Traffic volume measures

Initiative V: TMG own mechanism to support activities in respective sectors.

- Emission Trading System
- Program to encourage and support small business and household energy saving efforts
- Study on tax reduction and taxation

Source: Tokyo Climate Change Strategy , 2007

As 37% of the emissions are concentrated in the business sector Tokyo Metropolitan Government imposes stricter regulations than those of the central government, particularly in large facilities. Existing buildings are obliged to reduce their emissions and enter the emission trading program while new buildings need to comply with thermal insulation performances and energy-saving performances.

Tokyo Emission Trading System is applicable only to those business establishments whose annual usage of fuels, heat and electricity is 1,500 kL or larger on a crude oil equivalent basis. It is the first urban cap and trade system and will cover around 1400 installation of

which 1100 are business facilities and the remaining are industries facilities. Starting in April 2010 and following two compliance periods (2010-2014 & 2015-2019), Tokyo's ETS is planned to reduce emissions by around 17% from the base year's level. Allowances are allocated following grandfathering principle. Participants are required to report their verified emissions to Tokyo Metropolitan Government. Banking is allowed but borrowing is not. A Monetary fine will be imposed (500.000 yens) when violating orders and fact of violation will be released to the public

The sector-by sector emission reduction targets for Tokyo Metropolis according to master plan are the following[9]:

- By 2020 (reference year 2000)
  - Industrial and commercial sectors: reduce approximately a mere 10% in overall (by about 7% in commercial sector alone)
  - Household sector: reduce around 20%
  - Transport sector: reduce around 40%
- Renewable Energy Use Targets: heighten the percentage of renewable energy in energy consumption of Tokyo up to around 20% by 2020.

Achievements

Since 2002, the TMG has been operating the Planning System for Measures against Global Warming, making it mandatory for large business establishments to calculate and report the amount of their GHG emissions and set and announce reduction targets. In 2005, the TMG also started to provide guidance related to reduction efforts, evaluate reduction plans and announce the results of the evaluation.

In 2005, the TMG formulated a global warming control program, under which the TMG is making efforts to reduce GHG emissions; for example, TMG-owned facilities are actively installing energy-efficient equipment and introducing renewable energy. In order to lead actions by example the TMG has been releasing official announcement regarding GHG emissions from its own facilities every year since 2000. Furthermore, TMG formulated the "Global Warming Control Program" in 2005 with a goal to reduce the GHG emission level by 10% in 2009 compared with the 2004 level. See Table 2 for achievements in terms of GHG reductions.

Table 2. CO_2 emissions levels from TMG owned facilities

	2004	2005	2006	2007	2008
CO^2 [t-CO^2]	2,276,434	2,200,622	2,142,108	2,087,319	2,084,847
Reduction [%]		- 3.3	- 5.9	- 8.3	- 8.4

Source : http://www.metro.tokyo.jp/INET/OSHIRASE/2009/12/20jcp300.htm (In Japanese)

[9] http://www.kankyo.metro.tokyo.jp/kouhou/english/master-plan/pdf/part2-chapter1-section1-1~2.pdf

3. Road maps

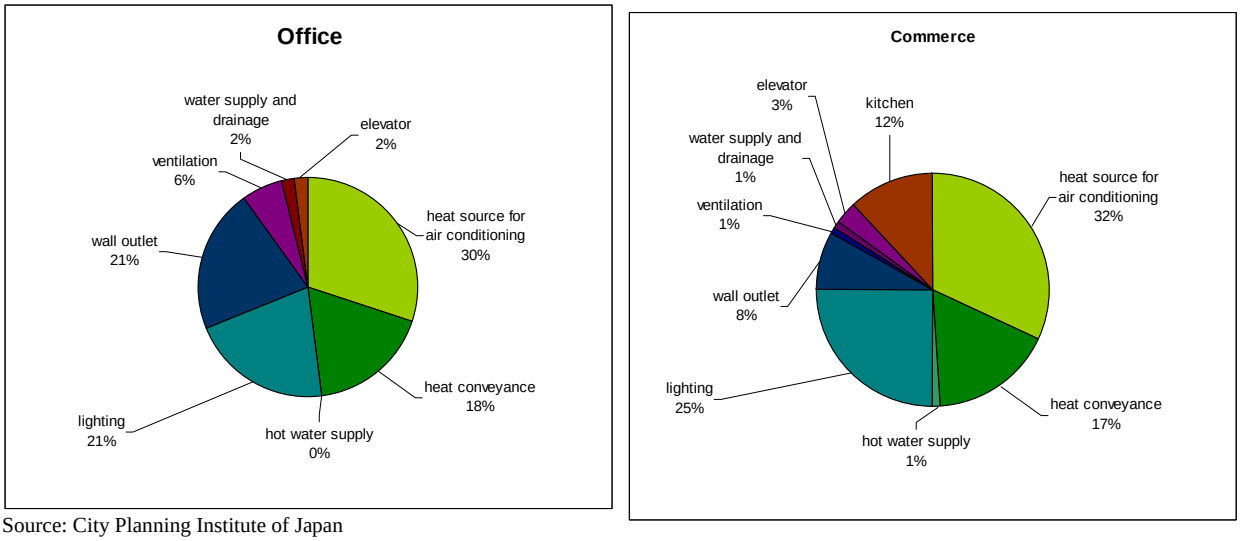
GHG emissions reduction

The roadmap of the emission reductions in Tokyo needs to be envisioned by a combination of measures in the supply and in the demand side. The expected passage to cleaner energy sources on the supply side is certainly going to help reducing the overall emissions. For instance, if TEPCO's nuclear facility utilization rate is increased by 1%, CO_2 emissions can be reduced by about one million tones. If thermal efficiency in TEPCO's thermal power generation increases by 1% CO_2 emissions can be reduced by about 1,7 million tonnes. However Tokyo won't be able to attain the set of targets without counting on the demand side. While the introduction of reduction obligations creates a huge amount of pressure and could imply big investments, some of the energy efficiency policies are actually cost negative as the McKinsey abatement curve shows.

Buildings: heat pumps saving the day

Figure 15 shows how the main energy application emission sources in office and commerce buildings are heat conveyance, lighting and air conditioning. While replacing incandescent lights for LED is an easy and negative cost measure, adapting air conditioning and heating devices requires a more technical approach and bigger investments.

Figure 15. CO_2 emissions from buildings for business use in breakdown by energy application



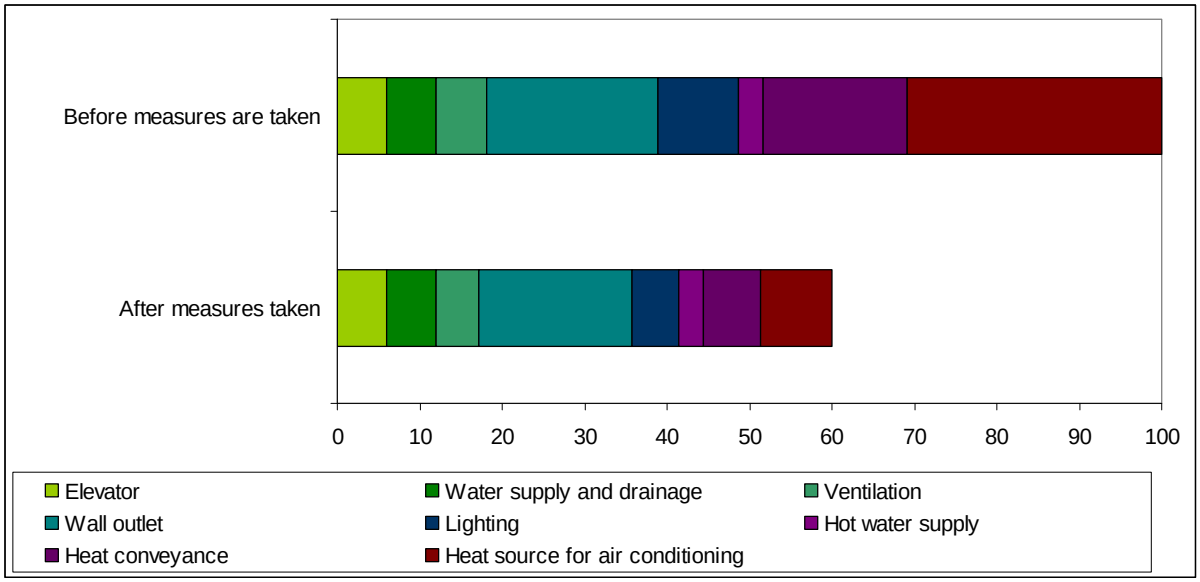
Source: City Planning Institute of Japan

In fact the City Planning Institute estimates that by introducing heat pumps and reducing loads, businesses could achieve an overall reduction of around 33%. While lighting, wall outlet and ventilation emission reduction measures added achieve reductions of only 8%. TEPCO estimations suggest that CO_2 emissions can be reduced by 67% by installing electric heat pumps systems when compared to a gas absorption refrigerator. As to the running cost, it can be decreased by around 27%[10]. Furthermore it seems that the use of heat pumps as heat source for air conditioning is not only indispensable for reducing CO_2 emissions for the

[10] Results depend on the conditions : building size, use, load, etc.

business sector but a basic component of *Tokyo Climate Change Strategy* to achieve emissions reduction objectives.

Figure 16. Measure for reduction in CO_2 emissions from buildings for business use



Heat source for air conditioning: reduction in loads and adoption of heat pumps
Heat conveyance: large temperature difference and rotation control of pumps and fans
Lighting: adoption of high-efficiency lighting equipment
Wall outlet: adoption of energy-saving equipment
Ventilation: CO_2 concentration control of ventilation in parking lots

Source: TEPCO , workshop 2009

Transport / land use: electric vehicles approach?

Even though the city of Tokyo transportation modal split is an energy efficient model, transportation emission policies still need to be envisioned as a part of the climate change challenge. With 43% of commuting done through the railway system, having cleaner energies on the supply side is without a doubt fundamental.

On passenger cars, fuel efficiency has improved considerably thanks to the development of new technologies by vehicle manufacturers. However, high fuel efficient vehicles, like hybrid cars still represent a minority. Of a total of 3'280.000 passenger cars registered in the Metropolis only 0.6% or 20.000 units are hybrids. With this in mind, one of the main policies on the transport sector is carbon reduction by utilizing electric vehicles.

A set of combined actions will probably be needed to reduce emissions in the transport sector[11]:

- Promotion of the diffusion of next-generation vehicles (Electric Vehicles and Plug-in-Hybrid Vehicles)
- Promotion of eco-driving
- Promotion of use and introduction of fuel-efficient vehicles
- Reduction of vehicle traffic

[11] Proposed by WEC- Japon

Some of the instruments of use to induce these actions[12]:

- Subsidy schemes for the purchase of next-generation vehicles and the installation of rapid-recharge chargers and the establishment of partnership with relevant companies
- Holding of lecture sessions in cooperation with wards, cities, towns and villages and other organization and the formulation and announcement of manuals
- Specification in writing of the obligation for introduction of energy efficient equipment and the obligation for making emission reduction efforts through the enactment of ordinances
- Trial introduction of the park-and-ride and car-sharing arrangements

Greening of energy

To achieve the objective of being a low carbon society, Tokyo needs to assure the supply of electric power of low CO_2 emission intensity. Three different strategies towards cleaner energy supply are being implemented by TEPCO, covering nuclear power, the improvement of thermal efficiency in power generation and the dissemination of renewable energies. While the TMG has not formulated any plan from the perspective of future stable supply of energy it is striving to create a low-carbon city by implementing measures to reduce energy consumption and introducing more renewable energy. These measures are based on the Tokyo Environmental Master Plan, which was formulated in March 2008.

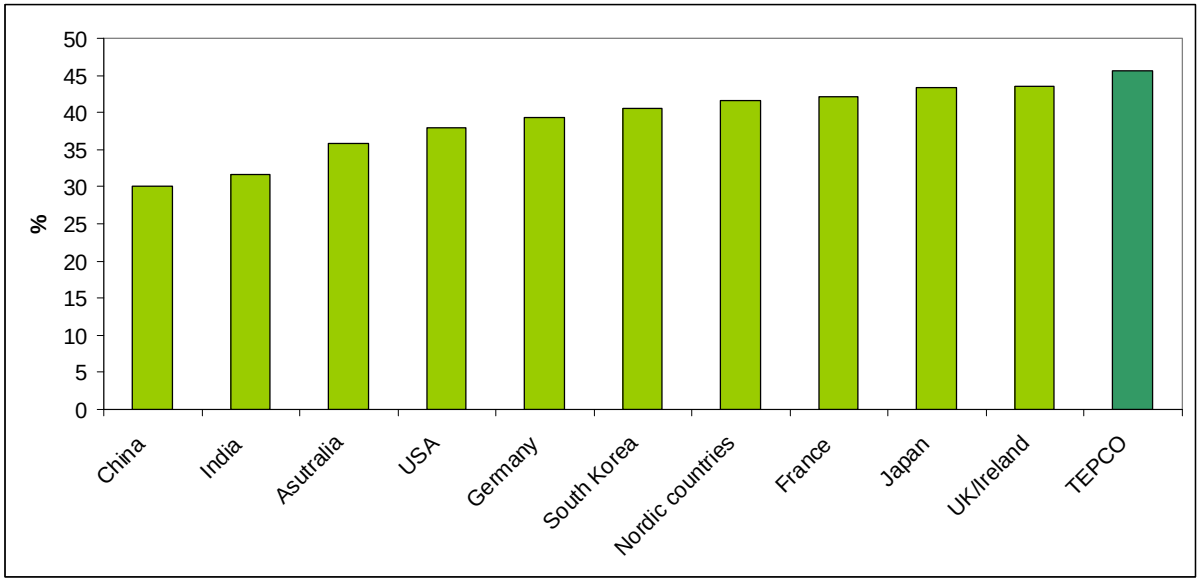
As nuclear energy is also a trump card for simultaneous achievement of stable supply, cost efficiency and environmental friendliness, nuclear power generation will be actively promoted. Even though TEPCO's nuclear power utilization rate decreased to 44.9% from 74.2% in FY2007 due to the impact of shutdown of Kashiwazaki-Kariwa Nuclear Power Station; projections is to expand the share of nuclear power to cover 48% of TEPCO's energy demand by 2020.

On the other side, the approaches to improve the thermal efficiency of thermal power generation are underway. By introducing and expanding the use of highly efficient equipment TEPCO has achieved supremacy in comparison with other countries thermal power generation efficiency.

`

[12] Proposed by WEC- Japon

Figure 17. International comparison of thermal power generation efficiency



Source: ECOFYS 'Comparison of Efficiency Fossil Power Generation"
(Notes): thermal efficiency values represent weighted average thermal efficiencies of coal, oil, and gas on the power generating end (LHV Standard). The thermal efficiency of independent power generation equipments I not included. The figure for TEPCO is FY2007 result. Other figures are 2004 values.

To increase the share of renewables in energy mix Tokyo has a set of projects in progress.

Type	Description of approach
Wind power generation	- Euros Energy Holdings Corp. Operate wind power generation equipment of 323,000 kW in Japan. - TEPCO's approach Plan wind power generation of about 180,000 kW in Higashiizucho and Kawazucho, Shizouka Prefecture
Photovoltaic power generation	- Ohgijma photovoltaic power station. 20,000 kW - New international freight terminal at Haneda Airport
Others	- Geothermal power station in Hachijojima Island (3,300 kW) - Plan to build 1,000 kW-class Tochikawa hydroelectric power station - Bio Fuel Co., Inc. Carbonize sludge that is produced in the process of sewage treatment and use it as fuel at coal-fired power stations - The Tokyo Electric Generation Co., Inc. Introduce hydro power generation equipment with a total capacity of 1,660 kW at 13 locations

Large-scale business operators which emit large amount of GHG will be obligated to reduce their emissions in a systematic manner under the mandatory emission reduction program. Although small and medium-size enterprises should make reduction efforts on a voluntary

basis, the TMG supports them through tax reduction and loan programs. Companies that have failed to fulfill their emission reduction obligation are subject to penalties, including the payment of a fine, the announcement of their names and the payment of the cost of purchasing emissions credits necessary for the fulfillment of the obligation. These penalties ensure the effectiveness of the mandatory emission reduction program. The rate of mandatory reduction is calculated on the basis of the past records of emissions and the status of introduction of energy-efficient equipment at each business establishment.

Regarding the diffusion of equipment using solar energy, the TMG, companies and NGOs are cooperating in implementing projects to raise awareness among citizens. According to materials prepared by the Ministry of Economy, Trade and Industry, the initial cost related to the installation of a solar PV power generation system at a new house can be recovered in around 10 years through the use of the subsidy scheme. Funds totaling \9 billion over a two-year period have been secured for the subsidy scheme for the introduction of equipment using solar energy. In addition, the TMG has established a subsidy scheme for the purchase of household-use equipment using solar energy in order to promote the introduction of renewable energy. It is also promoting the effective use of unused energy.

Regarding the subsidy for equipment using solar energy, the national government as well as wards and cities have created a subsidy scheme similar to the TMG's scheme. By using these schemes, the initial cost related to the installation of a solar PV power generation system at a new house can be recovered in around 10 years through the use of the subsidy schemes.

4. Discussion

It seems that climate change strategies in Tokyo were based mostly on voluntary approaches and public defamation campaigns. When these proved to be insufficient more restrictive policies were put into place. Also, with the introduction of the mandatory emission reduction program, ahead of the national government, the Tokyo Metropolitan Government is resolved to lead national and global efforts to combat global warming by implementing pioneering and highly effective reduction measures earlier than the national government. The creation of an Emission Trading System for commercial buildings is an innovation at world level. Furthermore, in the city of Tokyo one of the most promising technical solutions – Heat Pumps – is not only being proposed but has been put into service.

In addition, under the Fukuda government (which was in place in 2007-2008), the long-term national reduction target was set at a range of 60% to 80%. In order to achieve this it is elemental that all possible actions for the promotion of energy conservation and introduction of renewable energy in each of the industrial/commercial sector, household sector and transport sector are implemented. The ETS system introduced in the commercial sector is in particular important given the increased GHG emissions presented by this sector during the past years which account for around 40% of the overall emissions.