4 Demand Model

A comprehensive energy demand model was required in order to gain a realistic picture of Japan's energy system. An energy system consists of inputs and outputs, which vary over time. Energy demand is that part of the system which consumes energy in the form of electricity, heat and fuels provided by the supply side of the system, to make available services such as heating, lighting, transportation, communication and power for appliances.

In order to accurately analyse energy consumption, a demand model was built which reflected the actual demand in Japan in detail by identifying all areas where energy was consumed. It was then possible to detect all potential reductions. This was achieved by various means, such as intelligent design or replacement with efficient technologies.

Best available technologies (BAT)[15] were implemented in the industrial, residential and commercial demand sectors, where straightforward replacement would result in the reductions reported in this chapter. The transport sector was more problematic with regard to availability of the technology, although energy efficient vehicles (which consume less than 2.5 litres per 100 km) are now available on the market and the first fuel cell vehicles using hydrogen are now in the production stage, the necessary infrastructure for supplying hydrogen is not yet in place.

The renewable technologies required to meet the reduced demand were then determined in the supply model. A detailed explanation of supply and hydrogen can be found in the supply model section.

To analyse the potential reductions, the project team considered the total energy demand in sectors[16]:

- Industry
- Residential
- Commercial
- Transport

Each sector was investigated in terms of its current energy demand in its various energy forms.

Japanese energy demand data was taken from 1999, which was chosen as a reference year for the determination of the Energy-Rich Japan (ERJ) Demand Model. Research was conducted using

15. The term "best available technology" (BAT) is taken to mean the latest stage of development (state of the art) of processes, of facilities or of methods of operation, which indicate the practical suitability of a particular measure for producing electricity, heat or fuels and/or improving efficiency.
16. EDMC (2001).

both “bottom-up” and “top-down” approaches. By identifying and implementing the latest best technologies and environmental designs in all sectors of demand, and research into energy saving measures was applied in the bottom-up approach, such as using efficient vehicles and then calculating the decrease in demand. With the top-down approach, European studies conducted in energy efficiency and environmental designs were adopted in all sectors in Japan. Because of the advanced level of technology in Japan, European efficiency potentials had to be lowered by varying percentages according to the sector. This was supported by comparing the production of specific goods, such as steel production statistics in Europe and Japan. For example, the energy required to produce a ton of steel in Japan was compared to the energy required for producing a ton of steel in Europe.

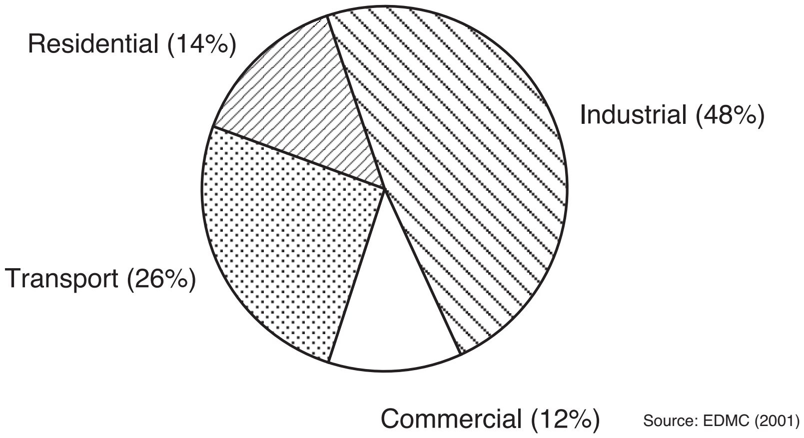


Figure 4 : Final energy demand per sector in Japan in 1999. Source: EDMC.

Lighting – A Cross-sector Technology

Lighting is considered in all sectors of demand, but deserves special mention here because of its cross-sector nature. Other areas of demand such as water heating are also cross-sectoral in nature, but are described in detail in the respective sectors of demand.

A number of measures can dramatically reduce the energy required for lighting in all sectors.

Among the largest reductions result from using highly-efficient lamps, efficient fluorescents and fixtures, occupancy detectors (up to 60% savings in one study[17] , electronic ballasts, daylighting (also daylighting using ‘light pipes’) and LEDs (for example in exit signs). Solar architecture and intelligent building design (reorganisation/retrofitting of existing buildings and the adapted planning of future buildings) reduces the general need for artificial lighting[18].

17. NEMA (2001).
18. ICCEPT (2002).

According to the IPCC[19], integrated building design projects have shown total energy savings of between 30% and 60% in the residential sector, and 13% to 71% in the commercial sector. The ERJ demand reduction estimates of 54% for both the residential and commercial sectors in Japan fits within these ranges.

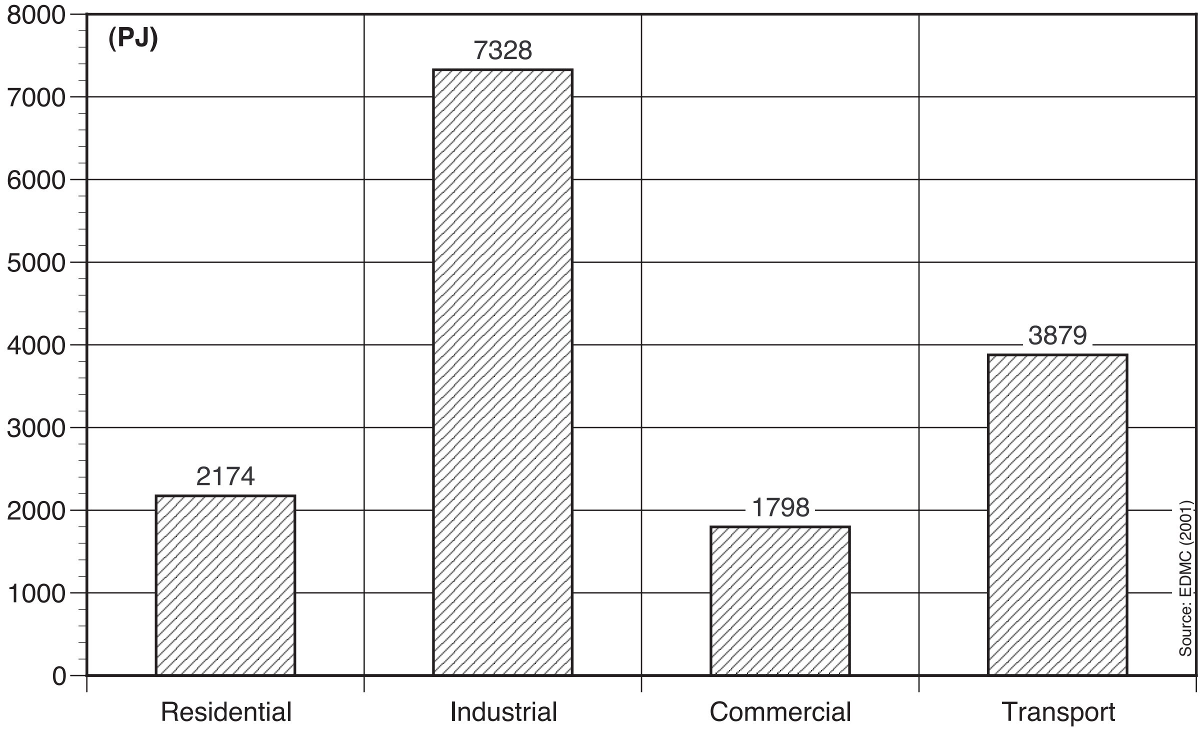


Figure 5 : Final energy demand in Japan per sector in 1999

4.1) Industry

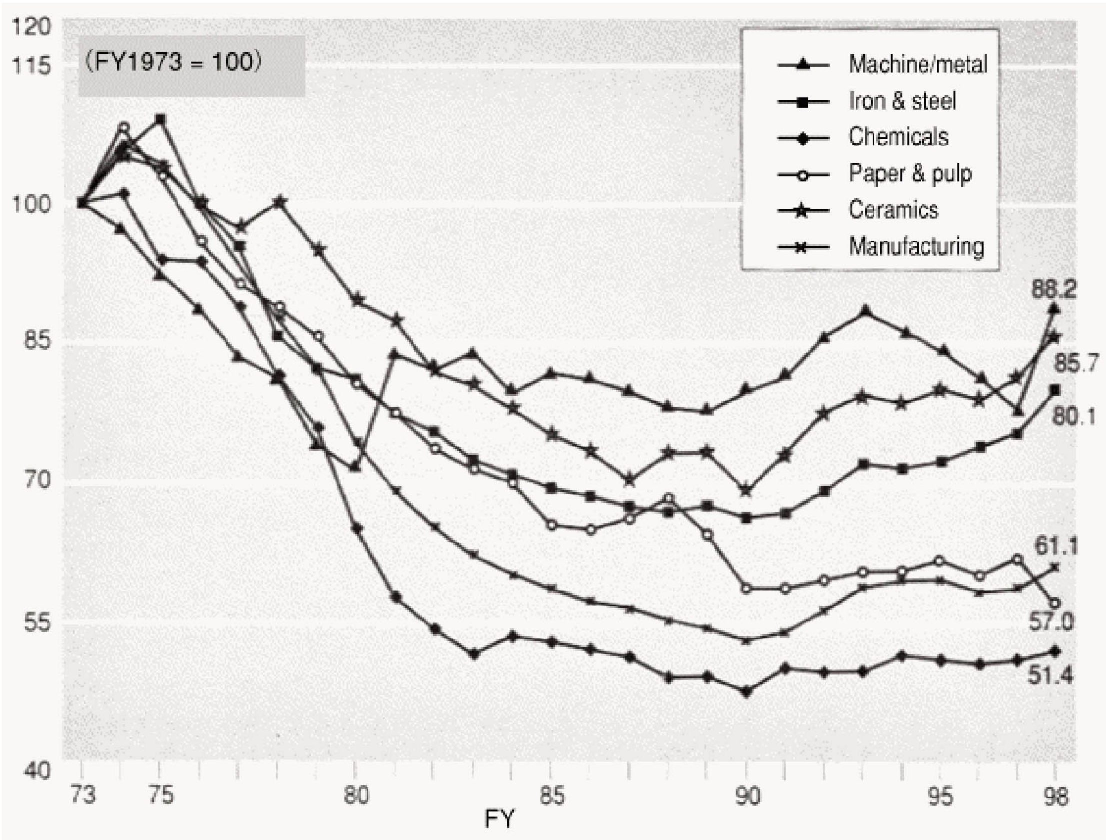
Japanese industry, which in 1999 consumed 48% of the total final energy demand, revealed energy savings of nearly 40% in the ERJ Demand Model.

The Figure 6 : "Changes in energy intensity of major industries in Japan 1973 – 1998" shows improvements in industrial energy efficiency since 1973. Note that efficiency has actually seen a general decline since 1990.

The sector was broken down into the following sub-sectors: agriculture, forestry and fisheries, mining, construction, food and tobacco, fibres, paper, pulp and print, chemical industries, ceramics and cements, iron and steel, non-ferrous metals, metal and machinery, and other industries.

19. IPCC (2001b).

The chosen approach was taken, based on bottom-up data from The Netherlands, Germany and Scandinavia. The technologies used in both regions are very similar (e.g. for steel production, chemical products etc). European industries are efficient but in certain branches their efficiency is less than in Japan. As Japanese industry is one of the most efficient in the world, the potential increases in efficiency found in Europe were reduced in certain cases to reflect this. This difference in potential was estimated by comparing existing Japanese-European studies for particular branches (e.g. iron and steel, chemical and cement). Many possibilities for reducing energy demand in industry were discovered using this method.



Source: Energy Conservation Centre of Japan[20]

Figure 6 : Changes in energy intensity of major industries in Japan 1973 – 1998

Because of the diverse character of the industrial sector, possible energy efficiency improvements were estimated sub-sector by sub-sector. Branch specific investigation would definitely have been better, but would be extremely time and cost intensive. However, some overview studies exist (AEA (2000), Bach (1993), de Beer (1994), ISI (2001) etc.), which are based upon approximately one thousand detailed investigations in total (made within the last 15 years).

20. Prepared based on EDMC (2000).

As with most industrialised countries, the chemical, then the iron and steel industries are the most energy intensive, followed by the ceramics and cement industries. In the chemical industry, savings of 35% came from measures such as adopting membrane processes, electronic control systems, fuel switching, heat recovery, better efficiency, hydrogen recovery, better integration of hot and cold streams, entirely new processes (such as the ICI AMV process for the synthesis of ammonia), overall good housekeeping and energy management[21]. In the ceramics and cement sector, changing the process from wet to precalciner kiln conversion saves 46% of the total energy in cement production (a saving of 1.1 GigaJoule per ton during production).

Improvements in furnace design and efficiency alone offer a large saving potential by using heat recovery with gas-fired burners for industrial furnaces. This technology makes furnaces more efficient by recovering waste heat from exhaust flue gases to preheat combustion air. According to one study, the conservation potential for the industrial sector from using such furnaces represents ten percent of the total industrial energy consumption. Simply by using the most efficient pumps and piping systems, a 70% reduction in energy use for pumping can be achieved, resulting in a potential three percent reduction in the industrial electricity demand. Other examples are using steamless brewery (using hot water at four different temperatures; using pinch-point methodology) leads to a 60% reduction of energy demand in this process. Heat recovery, burner optimisation, membrane techniques, energy management and good housekeeping are only a few examples of energy demand reduction options[22]. Good housekeeping and energy management is estimated to reduce the overall final energy consumption by at least five percent in all sectors of industry[23].

The technical potentials in this report express the maximum potential possible using all technical options, whereas economic potential describes the energy reductions that can be afforded within a certain timeframe. For example, the technical reduction potential in the mining industry lies between 50% and 70% for fuels[24] (depending on the fuel type), whereas the economic reduction potential between 1990 and 2015 was estimated at between 43% to 59%[25].

4.1.1) Agriculture, Forestry and Fisheries

Investigating the efficiency potentials for this sector was quite difficult because no detailed data of the sector was available. Therefore, only a rough estimation can be made. In the agriculture branch, fuels are mainly used for mobile farming equipment (tractor, trucks etc.), greenhouses and

21. Worrell, E. et al. (1999).
22. AEA (2000), Bach, W. (1993), de Beer, J. et al. (1994), de Beer, J. (1998), Prognos/EWI (1999).
23. de Beer, J. et al.(1994).
24. Polenz, C. (2002).
25. de Beer, J. et al. (1994).

space heating. Electricity is mainly used for lighting and different operations in farmers' buildings. In forestry, fuels are also used for mobile equipment but the share for greenhouses and space heating is smaller as well as the use of electricity. In the fishery industry, mainly fuels are used for boats, cooling, the whole equipment etc. Electricity is always generated directly onboard.

Therefore, the experiences of corresponding branches and technology areas (transportation, cooling, lighting, electric motors and drives etc.) have been used for estimating the reduction potentials. In Europe a 60% reduction is seen as possible.

A reduction potential of 52% was calculated in this sector for Japan.

4.1.2) The Mining Industry

The German forecast from EWI/Prognos (1999) shows a reduction of about 70 % for fuels and 32 % for electricity by 2020. The reason is a mixture of technological progress and structural change, where the main aspects are improved performance, better equipment, fuel switching (favouring natural gas), increasing trade and decreasing production. One should be aware that this is not a potential estimation but a forecast; potentials must be even higher.

Polenz, C. (2002) tried to estimate the technical potential in the mining industry. Due to his analysis, this lies between 50% and 70% (this varies with the fuel type) and for electricity by about 40%. On the other hand, de Beer, J. et al. (1994) analysed the economic reduction options between 1990 and 2015, which are shown as 43% to 59% for fuels and 35% for electricity. They were not able to include all possible measures, so potentials must also be higher than presented.

Following Bach, W. (1993), fuel consumption can be decreased by over 30% and electricity by nearly 40% by 2020 by using better equipment and more efficient transportation systems. The diffusion is assumed at a medium rate, therefore technical potentials are higher.[26]

A reduction potential of 39% was calculated in this sector for Japan.

4.1.3) Construction Industry

The construction industry in general is a sector where not much attention has yet been given to energy saving. Energy consumption can be divided into fuel for mobile equipment and asphalt-mixing installations and electricity for various appliances.

26. Advances in technologies since the publication of the Bach study would show increased potentials.

Polenz, C. (2002) estimated a technical potential of about 65% taking more measures into account (more efficient mobile equipment and trucks, burner optimising, improved insulation, heat recovery etc.), but the potential shown does not fit exactly to this branch. de Beer, J. et al. (1994) shows an economic reduction potential of about 27% by 2015 due to burner optimising, heat recovery, drum mixing installation, better mobile equipment etc. EWI/Prognos (1999) assume a reduction of about 18% by 2020 compared to 1995, mainly due to improved motor drives and electronic regulation. In all studies, the electricity reduction potential is about 35%.

A reduction potential of 24% was calculated in this sector for Japan.

4.1.4) Food and Tobacco

The food and tobacco industry consumes heat at different temperature levels, but the processes are very often not optimised so that there is still a great energy saving potential.

de Beer, J. et al. (1994) revealed a techno-economic reduction potential of about 61% (ranging for the various branches inside the sector from 35% to 81%). Polenz, C. (2002) even speaks of a saving potential between 66% and 72%.

According to Bach, W. (1993), the demand reduction between 1990 and 2020 could reach 54% in total (sugar industry 64%, semi luxury industry 67%, and others 43%). The main measures would be heat-recovery systems, modern evaporation, continuous processes, combined use of compressors and gas turbines and the use of membrane techniques. In the German business-as-usual study by EWI/Prognos (1999) a reduction of 25% is forecast, but a lot of efficiency potentials are not yet included. AEA Technology plc investigated a 33% cost-effective saving potential, but they again only included a few measures due to time limitations.

On the electricity side, the range of the economic reduction potential is from 25% to 35% (again only for some measures) and for technical potentials of 49% (due to speed control, improved pumps and appliances etc.).

A reduction potential of 41% was calculated in this sector for Japan.

4.1.5) Fibres

Overall 80% to 95% of the fuel demand in this industry is consumed for process heating, about one third of this heat is used only for drying. The remaining percentage represents space heating. Heat recovery, retrofitting of the dryers, airless drying, gas heat pumps, improved insulation, good housekeeping and management, infra red pre-drying, dielectric drying in vacuum etc. can lead to significant reductions.

The most detailed analysis, which included all possible measures that are discussed, investigated a fuel saving potential of up to 73% [27], while other studies show lower values. Polenz, C. (2002) revealed potentials between 50% and 57%, these were calculated at the beginning of the 1990s, when some new technologies were not known (e.g. Bach, W. 1993 showed 54 %).

The more mid-term oriented studies of EWI/Prognos (1999) and AEA (2000) estimated a cost-effective reduction of about 30 % (forecast by 2020) and 37% (potential by 2015) respectively. In both cases, only some measures were taken into account.

Saving options for electricity are not as good as for fuel, but they are still high (technical conservation potential between 30% and 45% are due to different analyses). Possible measures are efficient motors, lighting, adjustable speed drives, heat recovery, retrofitting, airless drying, gas heat pumps, improved air conditioning etc. Even in the business as usual forecast by EWI/Prognos (1999) the reduction would be 30%. AEA (2000) also showed some cost-effective measures that would lead to a reduction of 37% by 2015.

A reduction potential of 50% was calculated in this sector for Japan.

4.1.6) Paper and Pulp

The entire sector can be divided into paper mills, paper converting industries and corrugated board manufacturers. In the period from the seventies until 1990, the specific primary energy requirement dropped in the mill industry due to savings in the final heat demand and the application of cogeneration. The production of pulp out of wood is an energy intensive process; depending on the pulping process the net primary energy consumption varies from 11 GigaJoule per ton to 13 GigaJoule per ton of pulp.

Although the production lines have been well known for a long period, there are still a lot of saving options. Consumption could be economically reduced by 22% by using continuous cooking processes and efficient pumps, making various process modifications and optimisations and introducing recycling systems [28] or 28% [29].

Detailed analyses even investigated techno-economic options of about 67% energy demand reduction (69% for paper mills) [30] as well as a technical potential of about 83% (but compared

27. de Beer, J. et al. (1994).
28. Martin, N. et al. (2000).
29. EWI/Prognos (1999).
30. de Beer, J. et al. (1994).

with 1990) [31] . Therefore, industry also has to implement energy management systems, completely covered drying sections, better insulation of the hood condensation etc.

Technical electricity demand can be diminished by up to 75% [32] due to measures such as efficient and direct drive motors, more efficient pumps, energy management, improved lighting, adjustable speed drives, efficient machines on all levels, new pressing techniques (e.g. extended nip press) etc. The economic potentials are revealed as 20% [33] (only a few measures) to 48% [34] (the entire range of options).

A reduction potential of 49% was calculated in this sector for Japan.

4.1.7) Chemical Industries

The chemical sector is the major energy consumer in Japanese industry. The sector is very diverse; it can be divided into various sub-sectors like fertiliser-production, the petrochemicals, inorganic chemical, synthetic resins, pharmaceutical and others. Therefore, it is hard to analyse the possible saving potential for this sector, but nevertheless, some good estimates exist.

Bach, W. (1993) investigated a technical reduction potential of about 57%, Polenz, C. (2002) even 60% to 70%. According to de Beer, J. et al. (1994), 32% of the demand could be reduced economically, but not all possible measures have been included. AEA (2000) on the other hand showed a cost-effective saving potential of 37% by 2015. That corresponds with some very specific analyses made by Worrell (1994) for fertiliser (44 % reduction options), plastics (ten %) and others. Very interesting in this case is the business as usual study by EWI/Prognos (1999); the authors foresee a reduction in the German chemical industry (which is already quite efficient) of 53%.

However, all of these investigations belong to measures like membrane processes, electronic control systems, fuel switching, heat recovery, better efficiency, hydrogen recovery, better integration of hot and cold streams, entire new processes (like the ICI AMV process for the synthesis of ammonia) and overall good housekeeping and energy management.

The electricity saving potential is similar to the fuel case. Due to electronic control systems, well-dimensioned motors, adjustable speed drives, improving pressurised air systems, efficient lighting etc. energy requirements can be reduced by up to 55% [35] or even 70% [36]. Concerning de Beer

31. Bach, W. (1993).
32. Bach, W. (1993).
33. AEA (2000).
34. de Beer, J. et al. (1994).
35. Bach, W. (1993).
36. Polenz, C. (2002).

et al. (1994) 45% of the demand can be economically reduced (range from 26% to 50% for the various sub-sectors, not all possible measures are included). Without changing politics, the German electricity demand in the chemical industry will be reduced by 33% by 2020 [37] .

A reduction potential of 35% was calculated in this sector for Japan.

4.1.8) Ceramics and Cement

The manufacture of building materials and earthenware is the third largest sub-sector in Japanese industry from the point of view of energy consumption, although in the total size it is not comparable with the previously mentioned chemical industry. The ceramics industry in Japan actually saw a decrease in efficiency of over 15% between 1990 and 1998.

The energy demand in this sector would be reduced about 30% in the case of cement and up to 70% in the case of ceramics [38] by using improved recycling, furnace optimisation, heat recovery, insulating kiln wagons, improved process control, fast firing roller kilns, heat pumps for drying, fluidised bed reactors, good housekeeping etc. de Beer, J. et al. (1994) estimated economic reduction options from 43% for glass to 59% for pottery; cement is shown with 46%. Polenz (2002) produced results in the same range. Martin, N. et al. (1999) made a detailed analysis only for cement. According to him, the technical potential is 40% to 45%, the economic potential between 11% and 18%. Energetics (1997) made such an analysis for glass production and they show a technical reduction potential of about 40% to 50%.

Electricity reduction options are not so great, but there are still good opportunities, as in most of the other sectors. Bach, W. (1993) estimated a potential between 40% and 50% (depending on the branch); according to Martin, N. et al. (1999) and Energetics (1997) the potential for both cement and glass are quite similar to the fuel case mentioned above. The economic potential is given about 35% by de Beer, J. et al. (1994). In Germany, energy consumption in this sector will be reduced about 18% by 2020 in the conservative BAU case [39]. Measures include mill and sinter optimisation, new processing, furnace optimisation, heat recovery, efficient machines, fans and lighting etc. With furnace optimisation alone, heat recovery and a few other measures, energy demand can be reduced economically by 24% by 2020 under business as usual conditions [40] (1995 to 2020).

A reduction potential of 41% was calculated in this sector for Japan.

37. EWI/Prognos (1999.)
38. Bach, W. (1993).
39. EWI/Prognos (1999).
40. EWI/Prognos (1999).

4.1.9) Non-ferrous Metals

Energy consumption in this sector is dominated by the production of aluminium, which is very energy intensive. Therefore, most of the analysis potential is focused on this metal. However, the non-ferrous metal sector in Japan is not very important compared with the other industrial sectors.

On the fuel side, the reduction options are quite small. According to Bach, it should be possible to reduce consumption by 27% by using new processes etc. but Bach, W. (1993) made analyses relating to technical options. According to de Beer, J. et al. (1994) demand could be reduced by about 15% by utilising techno-economic reduction options (modern furnaces, new processes etc.). AEA (2000) on the other hand shows a cost-effective saving potential of about 21%. The most important reduction for fuels and electricity can be reached by changing the production structure, which means less primary production and more secondary production by the recycling of aluminium. On the basis of such an assumption, EWI/Prognos (1999) assumes a reduction in Germany of about 48% by 2020 through process improvements and reduced primary production.

In the case of electricity, the situation is different because efficiency potentials are much higher. Relating the use of new electrodes and processes, higher recycling rates, further development of the Hall-Heroult process and of furnaces, modern furnace technology, insulation, and good housekeeping, a reduction of about 69% is feasible [41]. AEA (2000) and de Beer, J. et al. (1994) both estimated the economic electricity reduction potential at 21%. Assuming significant improvements in the process technology as well as a change from primary to secondary production, EWI/Prognos (1999) forecast a reduction of about 59% by 2020.

An overall reduction potential of 31% was calculated in this sector for Japan.

4.1.10) Metal and Machinery

This sector again consists of different sub-sectors such as metal manufacturing, mechanical industries, electro-technical industries, transport equipment, foundries or engineering industries. These sectors are not so energy intensive as energy costs are only a small amount of the total production costs, and therefore the potential for energy conservation is lower. This minimum potential is also a consequence of a lack of knowledge concerning energy conservation in these companies (apart from foundries). More intensive research would reveal greater potential in this sector.

Fuels are mainly used for process heat and for space heating. Space heating can be improved by using insulation etc., but also the production and use of process heat can be further developed. Furnaces are often in a bad condition; waste heat can be recuperated.

41. Bach, W. (1993).

According to Polenz, C. (2002) technical potentials reach 85%. According to Bach, W. (1993) the technical potentials are less, but quite high with 41% (ranging from 23% to 54 %. It has to be taken into account that at the beginning of the nineties, knowledge about reduction options concerning space heating was not as good as today). EWI/Prognos (1999) foresees a reduction of about 36%. de Beer, J. et al. (1994) revealed an economic reduction potential of about 77%.

Electricity demand can be reduced by 42% <42> due to improved motor drives, electronic regulation, better appliances, speed control systems, and best available technologies for lighting etc. But potentials even seem to be higher because EWI/Prognos (1999) assumed a reduction of about 41% by 2020 in the business as usual case. The economic potential lies between 12% <43> and 20% <44>.

A reduction potential of 43% was calculated in this sector for Japan.

4.1.11) Iron and Steel

The iron and steel industry saw a 20% increase in efficiency between 1973 and the 1990s <45>, although a general reduction in efficiency has been seen in Japan between 1990 and 1998 (with a reference year of 1973=100), the peak efficiency was seen in 1990 at 66.2% of the 1973 level. Efficiencies have declined in most industrial sectors since then, especially in iron and steel and ceramics. (See Figure 6, "Changes in energy intensity of major industries in Japan 1973 – 1998")<46>.

Nevertheless, there are still large energy efficiency improvement potentials. Table A below lists the ranges of efficiency improvements reported from various sources. The wide variation (six percent to 60%) is due to differences in the basic assumptions used, plus the wide variation in the time period studied. The most recent study made of the technical potential was conducted for the IPCC (2001a), and described a current technical reduction potential of 10% to12% in Japan using today’s best available technologies. The same source however, also shows a potential increase in efficiency of about 30% if an energy efficiency index is used. The index is structured to show that if all processes operated at a best practice level, the index would be 100. Japanese iron and steel in 1991 showed a normalised efficiency of approximately 135, that is approximately 30% less efficient than its theoretical potential (with a statistical uncertainty quoted by the IPCC of 5%). Further to this, the efficiency of this sector peaked in the early 1990s and has continued to decline

42. Bach, W. (1993).
43. de Beer, J. et al. (1994).
44. Polenz, C. (2002).
45. IPCC (1995), ECCJ (1999).
46. EDMC (2001).

since (see Figure 6, "Changes in energy intensity of major industries in Japan 1973 – 1998") meaning that the reduction potential has actually increased since the IPCC reference year of 1991. The Wuppertal Institute in Germany estimated a reduction potential of 38% for the ERJ Study, which compares favourably with the IPCC figures.

A number of studies have reported reduction potentials above these figures. Bach, W. (1993) quotes a 48% reduction due to increased share of electric arc furnace (EAF), compared to the more energy-intensive basic oxygen furnace (BOF) and a large reduction of pig iron. EWI/Prognos (1999) quotes 55% for similar reasons, and Polenz (2002) quotes the largest reduction potential of 60%. It must be noted that reductions quoted here vary greatly due to the assumptions used. These include changing production methods involving the reduction of primary steel compared to secondary steel, process changes and other factors, which are discussed below.

Future efficiency increases have been estimated at around 1.5% to 2% per year on average for OECD countries from the year 2000 [47]. Taking this estimate, a reduction of around 30% can be considered possible before the year 2020.

Greater reductions would be possible by increasing the amount of secondary (or recycled) steel compared to primary production, as primary steel requires a large percentage of energy-intensive pig iron. The quality of secondary steel can be an issue due to contamination by impurities in the scrap, which could be addressed by considering the design of the primary steel during production [48]. This would mean a move toward closed loop recycling in the iron and steel industry. Japan is currently the second largest producer of steel in the world. In 1999, 74.52 million tons of pig iron and 94.19 million tons of crude steel were produced in Japan. In 2001, Japan imported over 126 million tons of iron ore and 63 million tons of coal, (approximately 70% from Australia) and exported six million tons of ferrous scrap[49].

An increase in material productivity would also mean a reduction in the demand for steel in products in Japan. This will have a dramatic influence on production in Japan in the future. Moves away from industrial production toward the service sector in Japan will also reduce the demand for steel. The last fifty years has seen dramatic changes in iron and steel production quantities and efficiencies. It is safe to assume that the future structure and size of the iron and steel industry in Japan will certainly look very different in fifty years time to today.

Considering all the above factors, a technical demand reduction potential of 30% was adopted for the ERJ Study without making changes to production levels or quality. This can clearly be considered as a conservative estimate, because tough policies for improving efficiencies and reducing

47. IPCC (2001b), WEC (1995).
48. IPCC (1995).
49. The Japan Iron and Steel Federation (2002).

energy consumption would serve to drive innovation and adoption, so that larger reductions could be achieved.

Source:	% increase in efficiency
AEA (2000) (see note 1)	15%
Assmann, D. (2001) (see note 2)	38%
Institute of Energy Economics, Japan (2000) (see note 3)	6%
Bach, W. (1993) (see note 4)	48%
de Beer, J. et al. (1994) (see note 5)	31%
de Beer, J. (1998) (see note 6)	22% to 34%, depending on process
EWI/Prognos (1999) (see note 7)	55%
IPCC (2001b) (see note 8)	10% to 12%, updated to 30%
Polenz, C. (2001): (see note 9)	55 to 60%
Polenz, C. (2002) (see note 10	60%
Price, L. et al. (2001) (see note 11)	19% to 45%
Worrell, E. (1994) (see note 12)	40% to 50%

Note 1: Cost-effective saving potentials with existing best-practice (no BOF or hotstrip mill).
Note 2: Based on a collation of other studies.
Note 3: 1996 estimate of the technical reduction potential.
Note 4: 1990 to 2020 reduction of about 48% (better processing, higher share of electro steel, strong reduction of pig iron.)
Note 5: 1990 to 2015 economic reduction options of about (blast and basic oxygen furnace, heat recovery, hot strip mill, etc.).
Note 6: Primary steel making 34%, direct reduction 22%, scrap based mills 30% .
Note 7: 1995 to 2020 reduction of about 55% (better processing, higher share of electro steel, reduction of pig iron).
Note 8: Current technical potential reported as 10%–12% in the iron and steel industry. Increased to 30% after contact with the author.
Note 9: Technical potential (depends on the fuel type).
Note 10: Summarised international iron and steel studies, made some calculations and estimated a technical potential reduction of up to 60%.
Note 11: Brazil 19%, China 45%, India 45%, Mexico 40%.
Note 12: Techno-economic potential.

Table 1 : Energy efficiency potentials of the steel sector from various studies.

4.1.12) Other industries

There are still many other industries that are not included in the sub-sectors mentioned above. Efficiency improvement potentials are hard to investigate due to the variation within this sub-sector. Therefore, a simple estimation based on plausibility was made for this study, which is quite sufficient for such a long-term reflection. The shown reduction potentials represent the average of the entire industry sector apart from ‘other industries’ and reduced for surety to 20%.

4.1.13) Summarising the Results for the Industrial Sector in Japan

Summarising the different studies about European energy efficiency potential as shown in Table 1 shows a summary of the different studies of European industries' current energy efficiency potential.

As previously mentioned, Japanese industry in general is the most efficient in the world; therefore, the potentials mentioned in Table 2 were adapted and reduced in certain cases. Some sectors where analysed more in detail (e.g. Iron and Steel, lighting). To calculate the efficiency difference between Europe and Japan a detailed analysis and comparisons by Ministry of International Trade and Industry (???) (chemical, iron/steel, cement) was used. With that data the weighted average difference in efficiency can be calculated as 13% for the entire industry (based on the energy consumption of each of the three sectors). That means that the potentials mentioned were reduced by these percentages to achieve the Japanese reduction potentials in the Table 3, "Energy saving potentials in Japanese industry (percentages compared to 1999)".

Figure 7, "Final energy demand per industrial sub-sector 1999 and ERJ Demand Model" shows the current (1999) and potential reductions identified by the ERJ Demand Model. The greatest absolute savings of 758 PJ were seen in the chemical industry due to the measures described above. The greatest percentage reduction of over 50% was seen in agriculture, mainly due to fuel savings.

Energy Saving Potentials (Europe)							
in %							
	Coal	Coke	Oil	Nat. Gas	Geothermal	Other Ren.	Electricity
Agriculture, Forestry and Fishery			60		20		50
Mining Industry			48				36
Construction Industry			27				35
Food and Tabacco			54	53			38
Fibers	64		63	61		40	39
Paper, Pulp and Print	60		62	61		50	53
Chemical Industries	48	48	48	48		30	50
Ceramics and Cement	47	47	46	45			41
Iron and Steel	20	55	38	37			15
Non-Ferrous Metal	28	28	27	26			45
Metal and Machinery	65	65	66	65			42
Other Industries	39	39	39	39			39

Table 2 : Energy saving potentials in European industry (percentages compared to 1999)

Energy Saving Potentials (Japan)							
in %							
	Coal	Coke	Oil	Nat. Gas	Geothermal	Other Ren.	Electricity
Agriculture, Forestry and Fishery			52		17		44
Mining Industry			42				31
Construction Industry			23				30
Food and Tabacco			47	46			33
Fibers	56		55	53		35	34
Paper, Pulp and Print	52		54	53		44	46
Chemical Industries	35	35	35	35		22	37
Ceramics and Cement	42	42	41	41			37
Iron and Steel	10	48	29	28			4
Non-Ferrous Metal	24	24	23	23			39
Metal and Machinery	57	57	57	57			37
Other Industries	34	34	34	34			34

Source: ERJ.

Table 3 : Energy saving potentials in Japanese industry (percentages compared to 1999)

Total Consumption								
in TJ								
	Coal	Coke	Oil	Nat. Gas	Geother-mal	Other Ren.	Electricity	Total Final Demand
Agriculture, Forestry and Fishery			426,131		4,146		13,568	443,845
Mining Industry			22,906				8,082	30,988
Construction Industry			174,456				4,146	178,602
Food and Tobacco			84,045	48,953			98,409	231,407
Fibers	1,131		89,866	8,333		1,926	29,606	130,862
Paper, Pulp and Print	51,089		118,844	30,067		94,430	127,052	421,482
Chemical Industries	28,434	5,905	1,803,894	80,109		1,340	234,925	2,154,607
Ceramics and Cement	209,213	16,415	165,034	15,787			78,894	485,343
Iron and Steel	397,655	882,328	119,472	60,427			284,883	1,744,765
Non-Ferrous Metal	5,109	8,417	48,157	15,452			69,556	146,691
Metal and Machinery	4,439	4,439	42,965	78,141			295,645	425,629
Other Industries	3,099	16,039	619,054	46,399			249,330	933,921
Total Industry	700,169	933,543	3,714,824	383,668	4,146	97,696	1,494,096	7,328,142

Source: EDMC (2001).

Table 4 : Final energy demand of Japanese industry (1999)

Energy Demand Industry								
in TJ								
	Coal	Coke	Oil	Nat. Gas	Geother-mal	Other Ren.	Electricity	Total Final Demand
Agriculture, Fore-stry and Fishery			202,578		3,424		7,642	213,644
Mining Industry			13,341				5,551	18,892
Construction Indus-try			133,476				2,883	136,359
Food and Tobacco			44,561	26,381			65,875	136,817
Fibers	501		40,610	3,911		1,256	19,561	65,839
Paper, Pulp and Print	24,420		54,740	14,110		53,353	68,468	215,091
Chemical Industries	18,471	3,836	1,171,810	52,039		1,047	149,177	1,396,380
Ceramics and Cement	120,716	9,472	96,710	9,393			49,782	286,073
Iron and Steel	359,220	461,318	84,546	43,419			272,833	1,221,336
Non-Ferrous Metal	3,864	6,367	36,845	11,957			42,325	101,358
Metal and Machin-ery	1,929	1,929	18,294	33,952			187,616	243,720
Other Industries	2,049	10,604	409,297	30,677			164,848	617,475
Total Industry	531,170	493,526	2,306,808	225,839	3,424	55,656	1,036,561	4,652,984

Source: ERJ.

Table 5 : Final energy demand of Japanese Industry, ERJ Demand Model

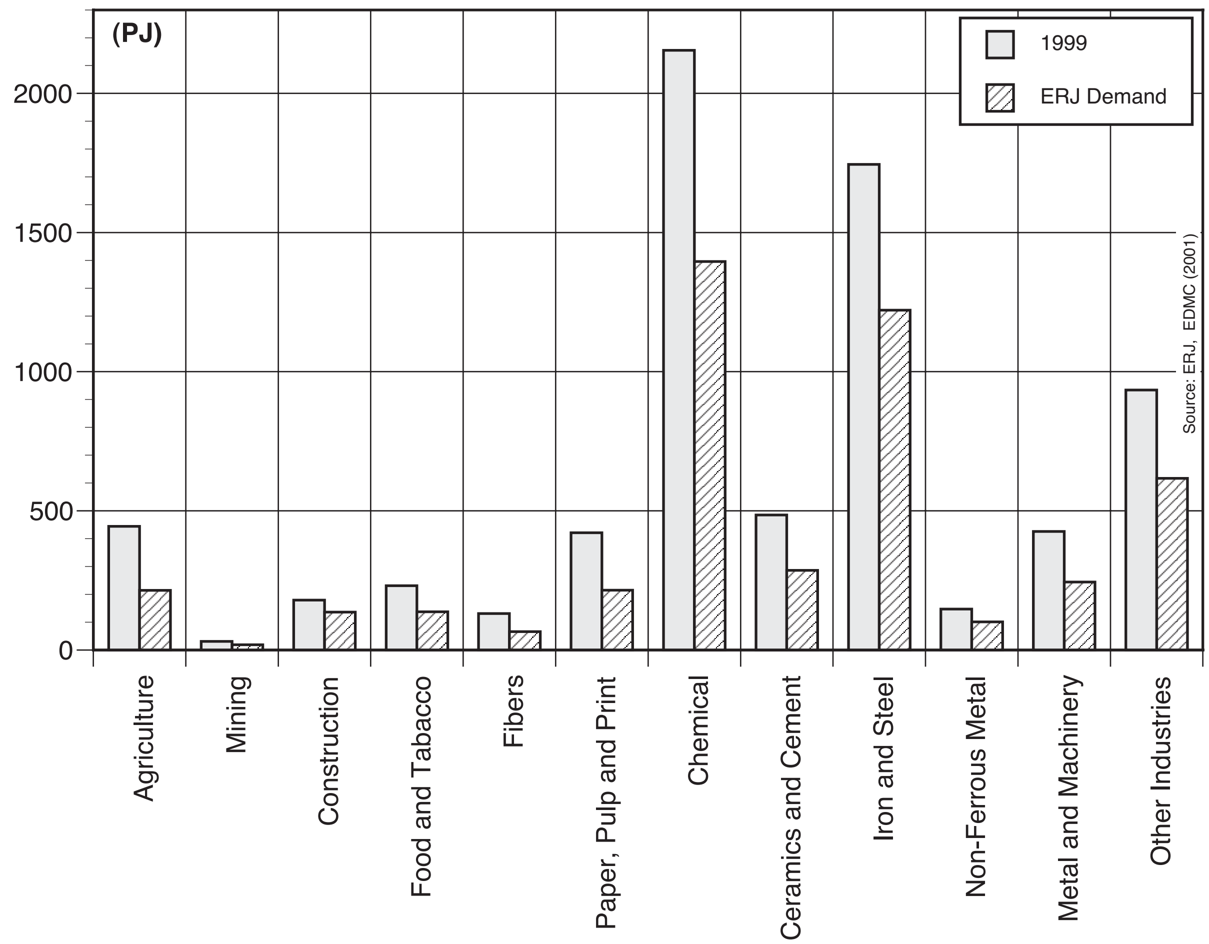


Figure 7 : Final energy demand per industrial sub-sector 1999 and ERJ Demand Model

4.2) Residential

The residential sector, which in 1999 consumed 14% of the total final energy supply, reduced its energy use by over 50% in the ERJ Demand Model.

Better analysis was available for the residential sector than for industry, as the range of technologies used is not as diverse. End-use areas of energy demand include mainly heating, cooling, cooking, lighting, hot water and motive power.

In order to determine reductions in residential energy demand, the logical starting point was to study improvements in house design and construction. A number of examples were found in Europe. The Enquete Commission of the German Parliament investigating environmental house design found potential energy reductions of 90% for Germany [50]. Improving building standards, using solar architecture and better air conditioning techniques resulted in large reductions in

50. Final Report Enquete Commission of the German Bundestag (2002)

energy demand. Other international comparisons of heating standards and construction possibilities also showed that in countries with moderate climate conditions similar to Japan, building standards show potential improvements of about 90% compared with today's average. In the case of Japan and other countries in the region, an improvement potential of only 73% was estimated. For achieving these potentials, Pfahl and Polenz only assumed existing construction options such as better insulation, advanced windows etc. and discussed their results with local experts.

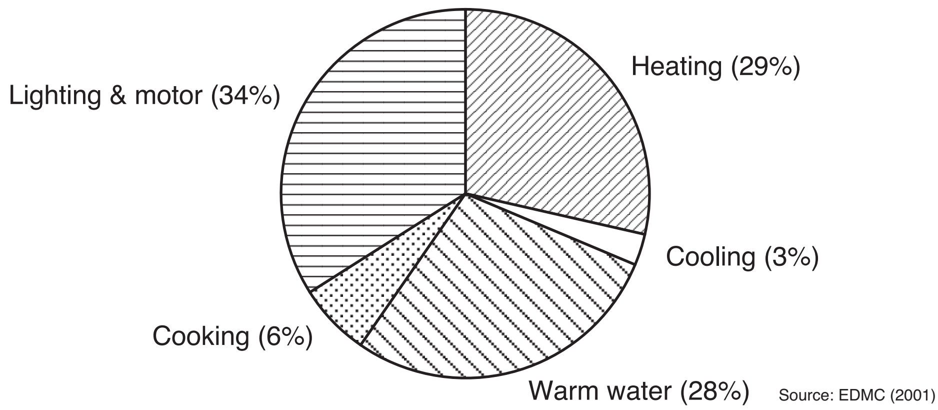


Figure 8 : Residential final energy demand in 1999

The savings potential for cooling represents only a part of technical improvements of air-conditioners. The value represents some revisions of Japanese appliance energy efficiency standards done by Murakoshi, C. et al. (1999) from the Jyunkankyo Research Institute (JYURI) and especially Nagata, Y. (2001) from the Central Research Institute of Electric Power Industry (CRIEPI).

Specific Consumption							
in kWh/m^2							
	Electricity	Oil	Gas	Coal	Bioenergy	Solar	Total
Heating	4.8	28.8	6.8	0.0			40
Cooling	3.9						4
Water	2.7	20.7	14.4	0.3		2.1	40
Cooking	2.1	2.5	4.4		0.1		9
Lighting & motor	48.1						48
Total	62	52	26	0	0	2	142

Note: average size per household: 90 m^2. Source: ERJ.

Table 6 : Specific energy demand in the Japanese residential sector (1999)

Total Consumption							
in TJ							
	Electricity	Oil	Gas	Coal	Bioenergy	Solar	Total
Heating	73,617	442,260	104,626	326			620,830
Cooling	59,792						59,792
Water	40,740	317,474	221,851	4,012		31,815	615,892
Cooking	31,641	38,760	67,107		879		138,387
Lighting & motor	738,966						738,966
Total	944,756	798,494	393,584	4,338	879	31,815	2,173,867

Source: Handbook of Energy & Economic Statistics in Japan (EDMC 2001).

Table 7 : Total energy demand in the Japanese residential sector (1999)

The next area of study was to optimise household appliances by introducing best available technologies. This was achieved by making a detailed analysis of energy demand, actual standards and best available technologies in more than 150 countries[51]. The results of the study were then used as the basis for comparison against current Japanese demand in the area of household technologies in order to calculate demand potentials.

Improving burner performance could lead to a decrease of cooking fuel/electricity demand between 11% and 14% in Japan. UNDP (1997) estimated even higher potentials (based on a study of the US Office of Technology Assessment) as well as German experiences and estimations [52]. WEC/IIASA (1998) also showed higher reduction options between 15% and 20%. Compared with the actual Japanese situation and Japanese estimates, the indicated saving potentials seem to be feasible, but still conservative.

Energy Saving Potentials						
in %						
	Electricity	Oil	Gas	Coal	Bioenergy	passive Solar
Heating						73
Cooling	40					
Water	8	27	30	7		
Cooking	11	14	11		47	
Lighting & motor	53					

Source: ERJ.

Table 8 : Energy saving potentials in the Japanese residential sector in % compared to 1999.

51. Pfahl, S. (2001).
52. Pfahl, S. (2001), Prognos/EWI (1999), Wolters, D. (2001).

Energy Demand Residential/Households					
in TJ					
	Electricity	Oil	Gas	Coal	Total
Heating					115,221
Cooling	35,875				35,875
Water	13,349	87,305	61,720	1,313	163,687
Cooking	28,160	33,334	59,725		121,219
Lighting & motor	347,314				347,314
Total	424,698	120,639	121,445	1,313	783,316

Source: ERJ.

Table 9 : Final energy demand of the residential sector, ERJ Demand Model

Water heating, electric appliances and lighting were identified as the most important energy consumers due to Japanese climatic conditions. Highly efficient lighting, efficient motors, a better match between motor, pump, piping and pumping demand, and best available refrigerators lead to an decrease of about 53% in the electricity consumption of households. Specific electricity consumption was decreased by a factor of five simply by using high-efficiency lighting. Best practice refrigerators only need one eighth of today's systems and air conditioners offer improvements of at least 40%, for example. Stand-by power was also seen as important. Many electrical household appliances such as TVs, VCRs, audio equipment and computers consume hundreds of milliwatts to several watts of power when they are idle. Intelligent design avoids such a wasteful use of energy [53].

The Figure 9, "Final residential energy demand 1999 and ERJ Demand Model in PJ" compares 1999 final energy demand in the residential sector to that in the ERJ Demand Model. The greatest absolute reduction in energy demand of 392 PJ was seen in lighting and motive power, and the largest percentage reduction of 75% was seen in heating.

53. Murakoshi, C. et al. (1999), Nagata, Y. (2001), Pfahl, S. (2001), Polenz, C. (2002), UNDP (1997), Wolters, D. (2001).

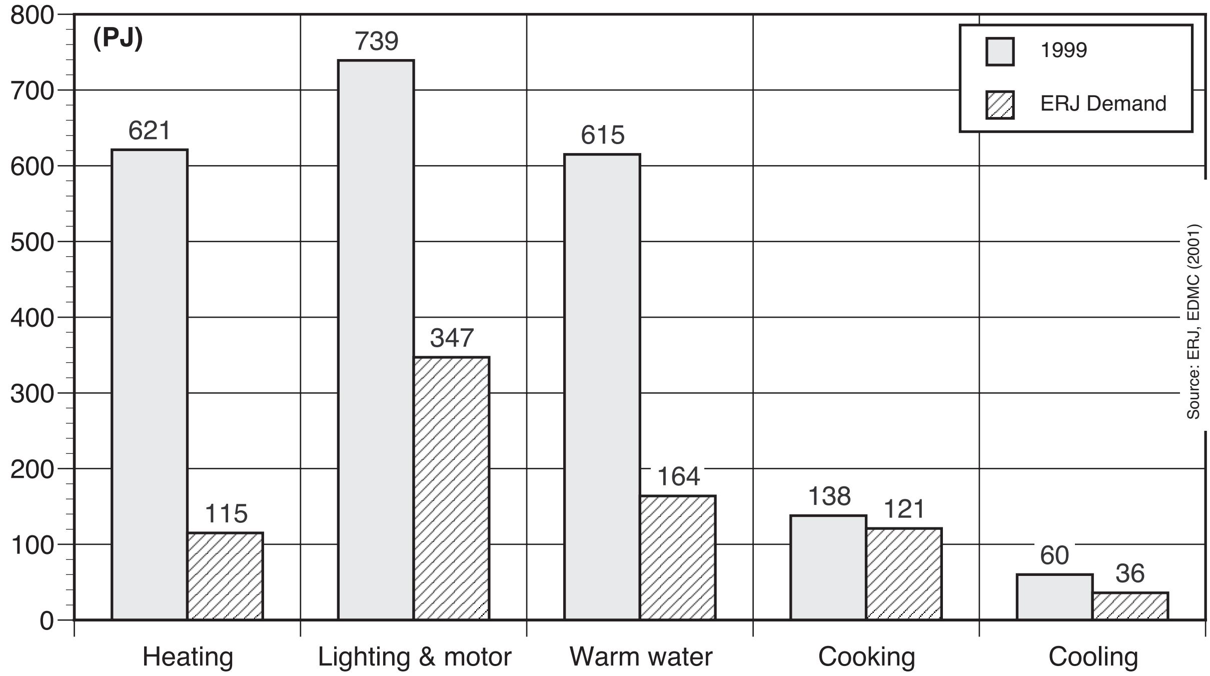


Figure 9 : Final residential energy demand 1999 and ERJ Demand Model in PJ

4.3) Commercial

The commercial sector consumes 12% of Japan's total final energy. A reduction of over 50% of the final energy consumption was found to be possible.

Branch-specific calculations were made in order to estimate the energy saving potential in the commercial and service sectors. Energetic analysis was more complex due to their diverse character, as all branches that did not fit readily into residential, industrial or transportation, such as handicrafts, trade or hospitals, were included here.

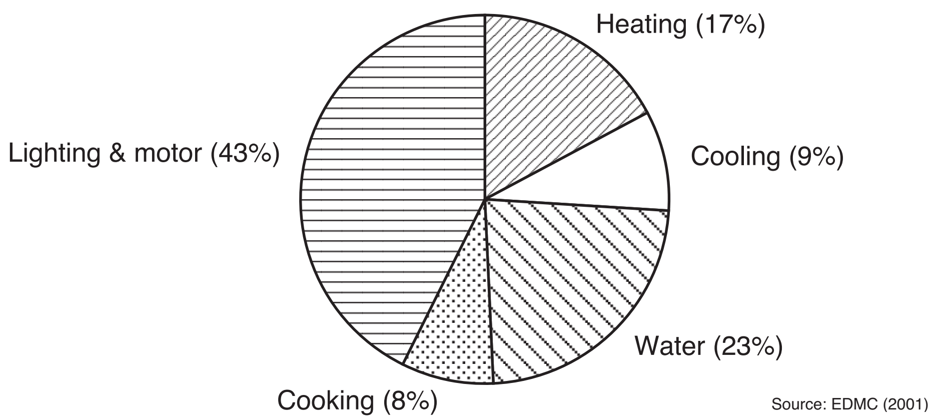


Figure 10 : Commercial energy demand in 1999

Specific Consumption							
in kWh/m^2							
	Electricity	Oil*	Gas**	Coal	Bioenergy	Solar	Total
Heating	5.0	60.5	6.6	1.0			73.2
Cooling	16.0	3.7	7.2				26.9
Water		40.2	22.7	4.0		4.5	71.4
Cooking			23.4		1.4		24.8
Lighting & motor	130.7						130.7
Total	151.7	104.4	59.9	5.0	1.4	4.5	327.0

* does not include LPG, ** LPG + Town Gas

Source: EDMC (2001)

Table 10 : Specific energy consumption in the Japanese commercial and service sectors (1999)

Total Consumption							
in TJ							
	Electricity	Oil*	Gas**	Coal	Bioenergy	Solar	Total
Heating	27,878	248,411	29,175	3,808			309,272
Cooling	93,768	21,838	42,312				157,918
Water		236,127	133,077	23,203		26,615	419,022
Cooking			137,172		8,189		145,361
Lighting & motor	766,867						766,867
Total	888,513	506,376	341,736	27,011	8,189	26,615	1,798,440

* does not include LPG, ** LPG + Town Gas

Source: EDMC (2001)

Table 11 : Total energy consumption of the Japanese commercial and service sectors (1999)

While some research into European branches exists no corresponding Japanese study could be identified. Another method of estimation was therefore used with different energy service demands, and analysed by first considering building construction and then applying BAT to appliances, similar to the methodology used in the residential sector. This led to a decrease of the total sectoral demand by 27% via improving building standards. By using the most efficient lighting systems, approximately 75% of electricity can be saved. The efficiency of motors, compressed air, pumps etc. also showed improvement potential, but not as much as with lighting [54]. The energy needed for cooling can be reduced by 30%.

Although it might be more difficult to reach a passive house standard for heating in the commercial sector, there are some new experiences that show this opportunity, e.g. Wagner Solar in Ger-

54. ISI (2001), Nagata, Y. (2001), Pfahl, S. (2001), Prognos (1999), Tsuchiya , H. (2001), UNDP (1997), WEC/IIASA (1998), Wolters, D. (2001).

many. Pfahl, S. (2001) again estimated the saving potential for different regions. As one can see in the Table, the assumed reduction potential is much lower than in the residential sector (19% compared to 73%). That means it is at the low end of the efficiency potential and only represents today's state of the art but not the recent experiences of new approaches and buildings.

The specific consumption for electric cooling agrees with the results from Nagata mentioned above – it is again a reduction of about 40% due to the better performance of electric air-conditioners. For the same reason, the German Fraunhofer Institute ISI estimated a savings potential between existing cooling systems and the most modern techniques of about 32% based on oil and of about 51% based on gas. One has to take into account that higher saving rates could be reached by using solar architecture approaches. The result would be a strong decrease in the cooling demand. Until today little experience exists, which still shows possible potentials of more than 30 or 40%. However, we have chosen the more conservative assumption.

The best available technologies for water heating are very similar to the residential sector, only the percentage reductions vary because of different state of the art technologies. The BAT rates that one can find in the last table are mainly based upon Tsuchiya, H. (2001), Wolters, D. (2001) and Prognos (1999). Tsuchiya made specific calculations for Japan, Prognos made very detailed analysis for the German service sector and Wolters combined those results with the OECD Asian region situation.

The efficiency of cooking with natural gas is already very good in Japan compared with other countries or with other energy carriers such as electricity. Therefore, reduction potentials are quite low (approximately 11%) due to some performance improvements [55]. Only in the case of bioenergy (that has a low share compared with natural gas) are reduction potentials higher at 47% [56].

Energy Saving Potentials (BAT)

in %

	Electricity	Oil	Gas	Coal	Bioenergy	Passive Solar
Heating						42.7
Cooling	9.6	1.8	4.9			
Water		31.6	17.0	3.7		
Cooking			20.9		0.7	
Lighting & motor	50.0					

Source : ERJ.

Table 12 : Energy saving potentials in the Japanese commercial and service sectors in % compared to 1999

55. Pfahl, S. (2001), Prognos (1999), Wolters, D. (2001).
56. UNDP (1997).

Energy Demand Commercial/Services						
in TJ						
	Electricity	Oil	Gas	Coal	Bioenergy	Total
Heating	5,289	47,133	5,535	723		58,680
Cooling	56,333	10,562	28,753			95,648
Water		185,429	99,756	21,712		306,897
Cooking			122,641		4,108	126,749
Lighting & motor	293,400					293,400
Total	355,022	243,124	256,685	22,435	4,108	881,374

Source : ERJ.

Table 13 : Final energy demand of the commercial and service sectors, ERJ Demand Model

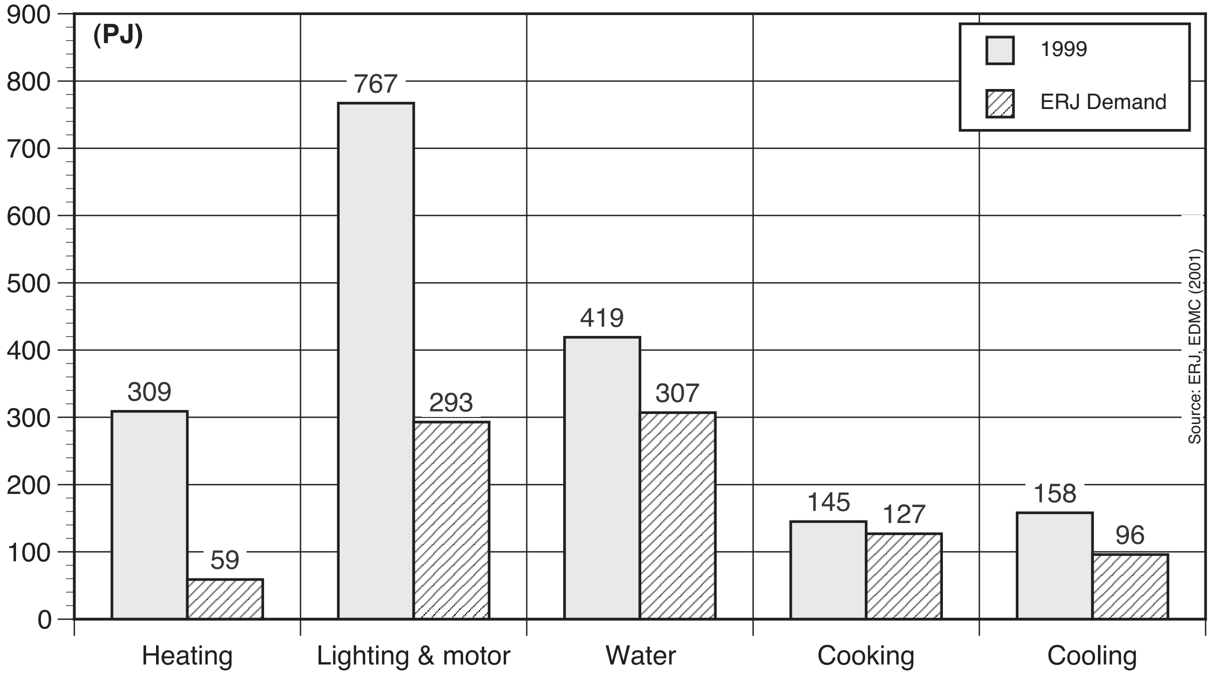


Figure 11 : Commercial final energy demand comparison

The greatest potential for reductions in electricity demand of 473 PJ was identified in commercial lighting and other electrical appliances, which were identified as more energy intensive than in the residential sector. The greatest percentage reduction of over 80% was seen in heating. Air conditioning was also seen as more relevant than in the residential sector.

4.4) Transport

The transport sector consumes over a quarter of the total energy and could reduce its energy demand by a massive 70%.

Transportation was divided into passenger and freight transport. Energy in the transport sector is mainly consumed in the form of oil-derived fuels, whereas electricity used for rail transport constitutes only a small percentage.

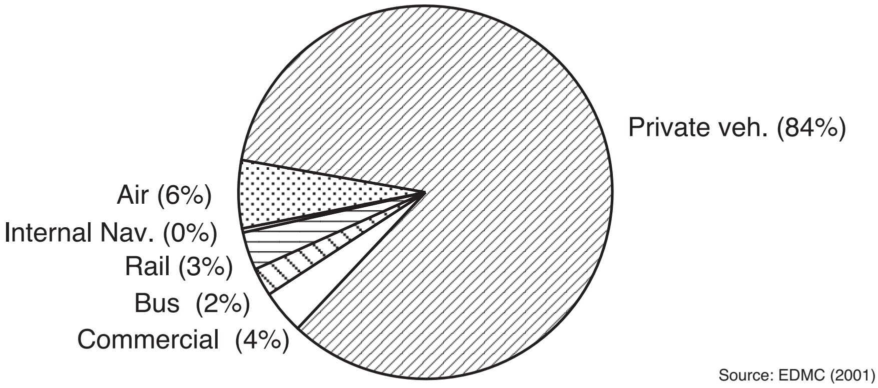


Figure 12 : Passenger transport 1999

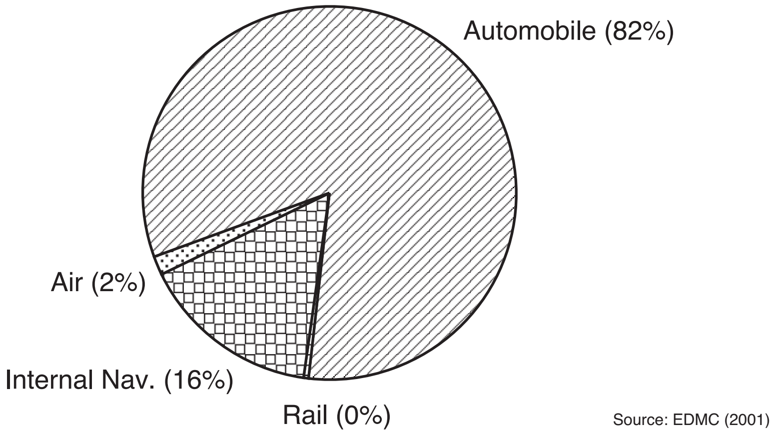


Figure 13 : Freight transport 1999

In Table 14, "Status of passenger and freight transport in Japan (1999)" the traffic volume and specific as well as total energy consumption for 1999 is shown.

Passenger Transport			
1999			
	Mio. Pkm	MJ/Pkm	PJ
Private vehicle	858,095	2.45	2098.0
Commercial	12,185	7.76	94.6
Bus	88,703	0.69	61.3
Rail	385,101	0.21	82.0
Internal Navigation	4,479	2.04	9.2
Air	79,360	1.85	146.5
Total	1,427,923	1.75	2493.2
Freight Transport			
1999			
	Mio. tkm	MJ/tkm	PJ
Road	306,156	3.73	1,140.7
Rail	22,541	0.26	5.9
Internal Navigation	229,432	0.94	216.1
Air	1,039	21.69	22.5
Total	559,167	2.48	1,385.6

Source: EDMC (2001).

Table 14 : Status of passenger and freight transport in Japan (1999)

The main improvements were seen in the use of the private car. Intensive research in this area has produced a number of options. Today's vehicles have the potential to be much more fuel-efficient using conventional fuels or by conversion to the use of hydrogen as a fuel. Vehicles in Japan currently achieve 12.6 km per litre of fuel[57]. The demand for fuel-efficient vehicles in Europe and Japan has prompted manufacturers to develop and introduce vehicles that are between 40% and 60% more fuel-efficient than the average passenger car today[58]. Volkswagen has demonstrated fuel consumption figures of one litre per 100km with its latest experimental vehicle.[59] Vehicles already exist on the market, which use three litres per hundred kilometres. The specific consumption for private vehicles in the ERJ Demand Model is 40 km per litre of fuel. This value can be reached by reducing weight, air resistance, decreasing acceleration and rolling resistance, improved motor technologies and transmission, using lighter materials and hybrid technologies. All the technologies of the „Hypercar“ concept by Amory Lovins can also be taken into account, but are not used here.

57. EDMC (2001).
58. Motor Vehicle Fuel Efficiency Initiative (2000).
59. Volkswagen test not necessarily specific to Japanese conditions.

Source: Greenpeace.

Figure 14 : The Greenpeace „SMILE“ car. The car is based on a series-production vehicle. Aerodynamic modifications, weight reduction and the implementation of a high efficient combustion-engine allowed to half fuel consumption while maintaining the cars power and performance.

Fuel cell cars use electricity generated by a hydrogen-oxygen chemical reaction. Fuel will almost certainly switch to hydrogen, but even when fossil fuels are used to produce hydrogen, the efficiency is double that of the combustion engine. For cargo transportation, changing all vehicles over to hybrids reduced the energy demand in that sector by over 40%. For passenger transportation, changing all cars over to hybrid vehicles conserves 45% of the total passenger energy demand, and with the more efficient fuel cell technology the percentage rises to 54%[60]. Taking further possible measures into account[61], specific consumption could be reduced by a factor of five to six.

Figure 15, "Transport energy reductions 1999 and ERJ Demand Model" shows that vehicles clearly offer the greatest energy reduction potential. The greatest absolute and percentage reduction of over 1,600 PJ or 77% was seen in private vehicles.

60. Tsuchiya, H. (2001).
61. Pfahl, S. (2001).

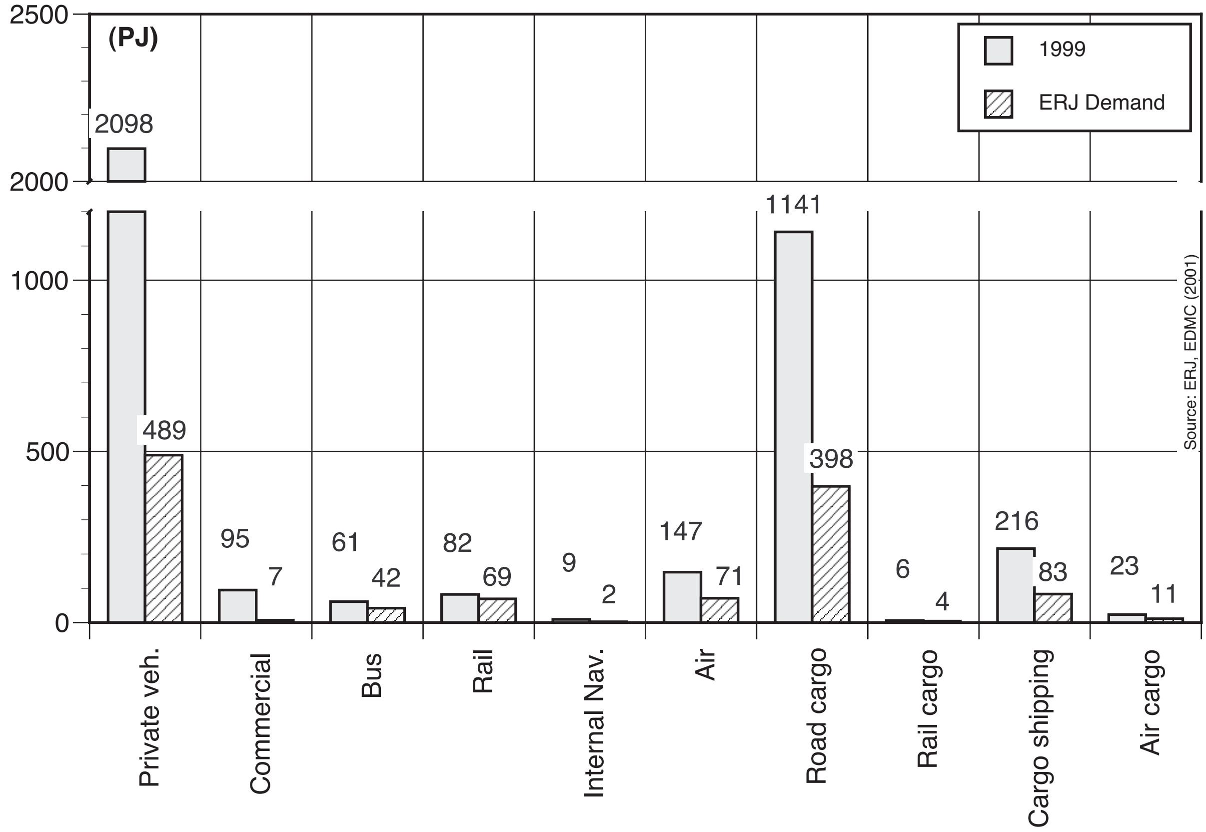


Figure 15 : Transport energy reductions 1999 and ERJ Demand Model

4.5) Combining the Results – ERJ Demand Model

Japan is one of the most advanced countries in the world in terms of its energy efficiency but nonetheless, improvements using best available technologies are still possible and would result in a significant reduction in energy demand from over 15,000 PJ in 1999 to about 7,500 PJ in the ERJ Model.

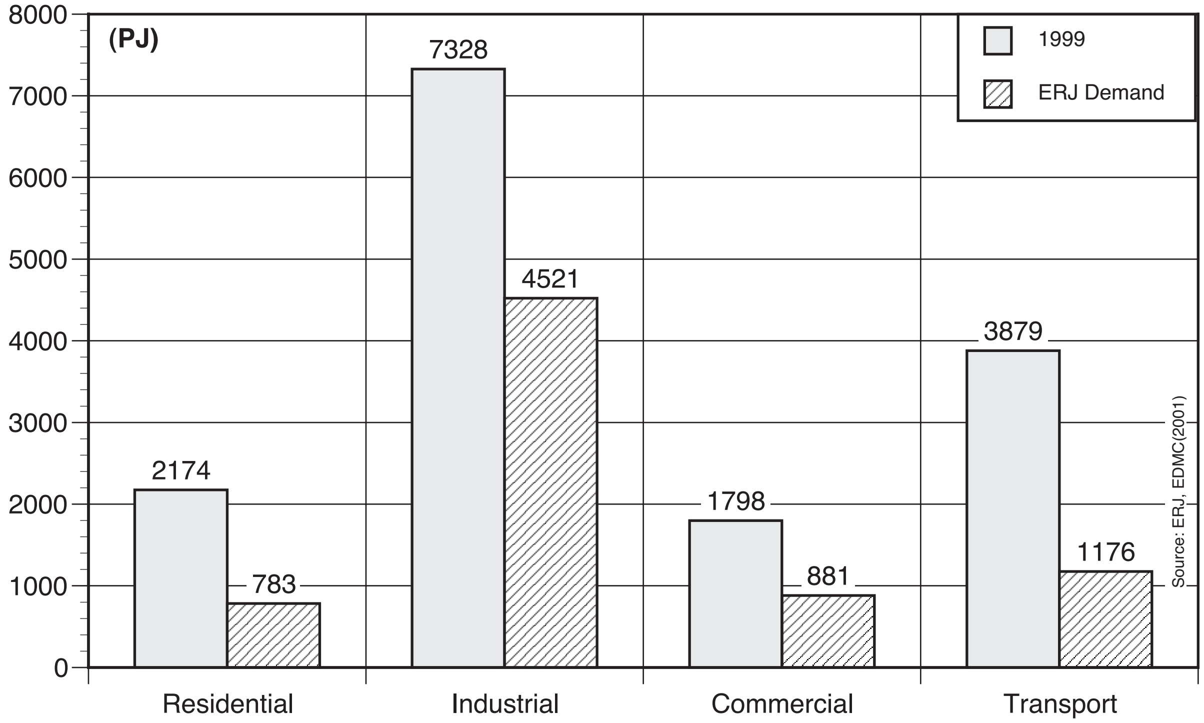


Figure 16 : Final energy demand, 1999 and the ERJ Demand Model

	1999		Energy-Rich Japan Demand Model		
	Energy in PJ	**Share**	**Energy in PJ**	**Share**	**Change**
Industry	7,328	48%	4,653	62%	-37%
Commercial	1,798	12%	881	12%	-51%
Residential	2,174	14%	783	10%	-64%
Transport	3,879	26%	1,176	16%	-70%
Total	15,179	100%	7,493	100%	-50%

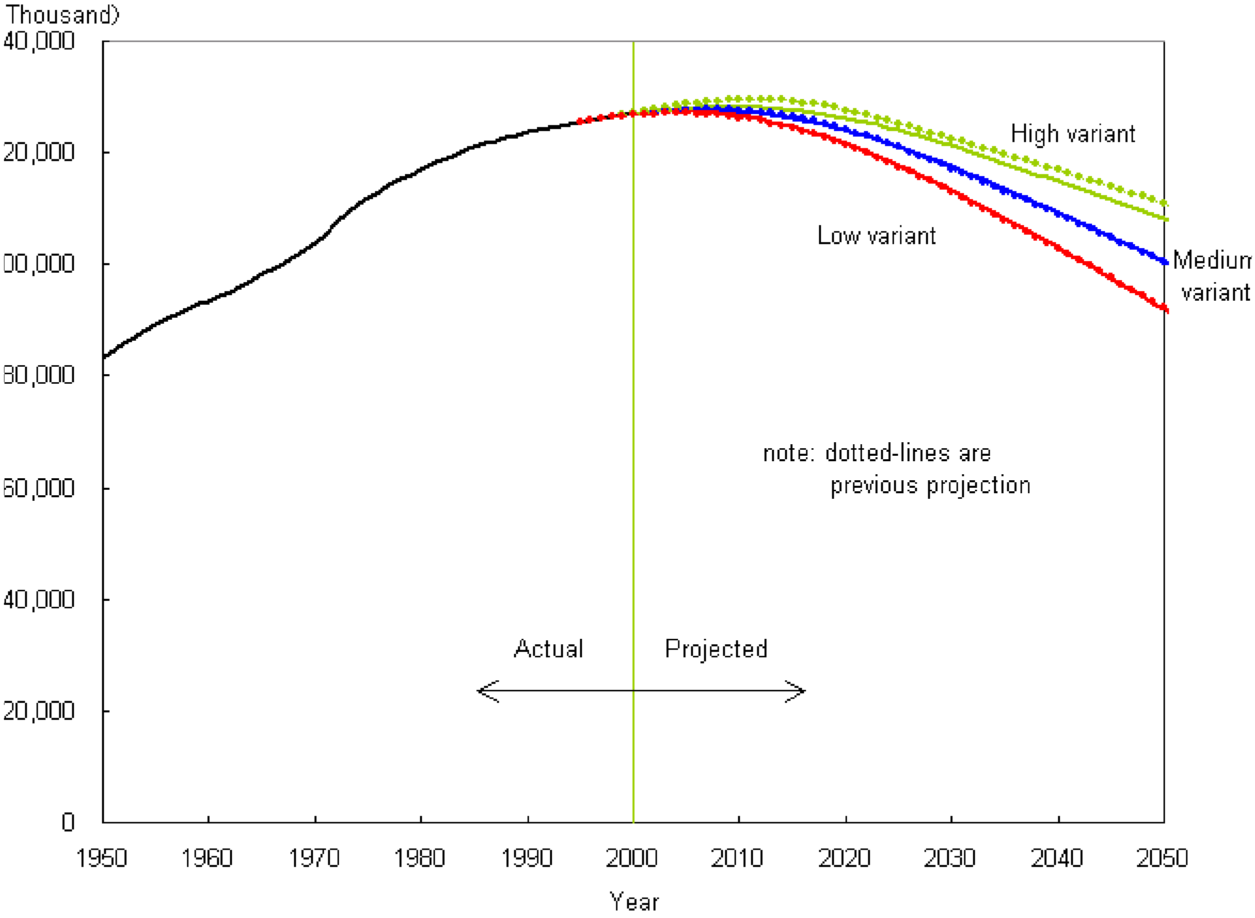
Source: EDMC (2001), ERJ.

Table 15 : The final energy demand 1999 and in the ERJ Demand Model

Our research revealed that with the same standard of living (in terms of energy services), a reduction potential of approximately 50% in energy demand exists in Japan. The greatest absolute reduction of over 2,800 PJ was seen in the industrial sector, with the largest percentage reduction of 70% in transport.

4.6) Greater Reductions Possible

The energy demand reduction envisaged for Japan is a conservative estimate of the potential savings as a number of factors that would have helped reduce demand were not included, such as, industrial changes and prototype highly efficient technologies. One factor that was assessed was that the total Japanese population is also expected to decline and the average age is set to increase[62]. Three scenarios consider this issue and are reported later in this report.



Source: National Institute of Population and Social Security Research (2001).

Figure 17 : Population projections. Japan 1950 to 2050

Employment in Japan is also moving away from the (higher energy consuming) industry sector towards the service sector. New jobs in information technology, working from home, changing travel patterns and new methods of communicating will also help to reduce energy demand[63].

62. National Institute of Population and Social Security Research (2001).
63. Statistics bureau and Statistics Centre, Ministry of Public Management, Home Affairs Post and Telecommunications (2001).

Japanese society is also changing its expectations regarding affluence, with a trend towards valuing free time and 'sufficiency' above wealth and possessions.

In addition, a huge energy saving potential exists with material optimisation, reduction, substitution, and product intensification, increasing product longevity and recycling. The concept of resource optimisation[64] is known as Factor 10. Schmidt-Bleek and the Factor 10 Club challenges industrialised nations to drastically reduce resources (and hence energy use). The concept closely follows the analysis of resource use and optimisation, known as MIPS (material input per unit of service), which demonstrates that a product function can have a much lower specific material requirement per unit of service.

Looking at the chemical and steel and iron industries, which are the biggest consumers in the industrial sector, a further reduction of 20% due to a decreased material intensity seems feasible.

Even the transport sector offers saving potentials that have not been outlined. The specific fuel consumption of private vehicles in the ERJ Demand Model was set to 2.5 litres per 100 km. Assuming a further reduction to 1.8 l/100km (a 28% reduction, compared to the ERJ Demand Model) results in saving almost 140 PJ of primary energy from fuels. Considering the same reduction for lorries saves another 110 PJ. In total a further reduction of fuel demand in the transport sector of nearly 250 PJ seems possible.

64. Schmidt-Bleek, F. (1993), Factor 10 Club (1994).