7 Conclusions

Bringing together the results of research into energy demand in the *ERJ Demand Model*, energy supply in the *ERJ Supply Models* and the SimRen computer simulation, it was shown that the goal of supplying Japan with a 100% renewable energy system, based on regional and external sources, has been achieved. Furthermore, a study of six possible scenarios demonstrated the options available in order to supply Japan with up to 100% energy from regional sources.

7.1) Demand

Japan is one of the most advanced countries in the world in terms of its energy efficiency, but nonetheless improvements using best available technologies results in a significant reduction in final energy demand of about 50% in the scenarios (from over 15,200 PJ in 1999 to nearly 7,400 PJ in Scenarios One, Three and Five, and to 5,850 PJ in Scenarios Two, Four and Six).

This reduction is a conservative estimate of the potential savings as a number of factors that would have helped reduce demand were not included, including possible industrial structural changes and application of prototype highly efficient technologies. The study did include studies of a decline in the Japanese population in three scenarios[<103>]. Employment in Japan is moving away from industry towards the service sector. New jobs in information technology, working from home, changing travel patterns and new methods of communicating will help to reduce energy demand[<104>]. Japanese society is also changing its expectations regarding affluence, with more people valuing free time above wealth and possessions in a trend towards sufficiency.

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[<105>] is known as Factor 10. Schmidt-Bleek and the Factor 10 Club challenges industrialised nations to drastically reduce depletion of 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.

103.National Institute of Population and Social Security Research (2001).
104.Statistics bureau and Statistics Centre, Ministry of Public Management, Home Affairs Post and Telecommunications (2001).
105.Schmidt-Bleek, F. (1993) and Factor 10 Club (1994).

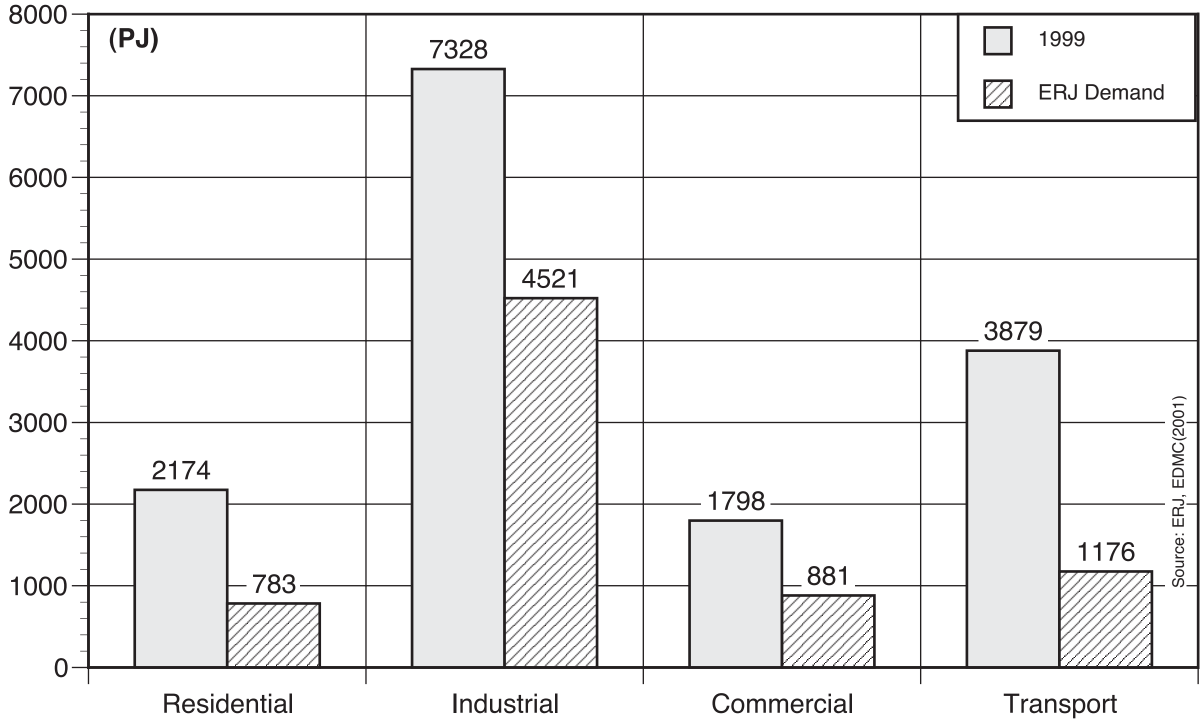


Figure 53 : Projected Japanese final energy demand according to the standard (1999) and the *ERJ Demand Model*

A basic overall reduction in final energy demand from nearly 15,200 PJ to under 7,500 PJ was determined, a reduction of over 50%, by introducing BAT in all sectors.

7.2) Supply

The *ERJ Supply Models* can produce all the energy using a combination of renewable energy technologies from regional and external sources or purely regional sources. Scenario One is described in detail in this report as this scenario is used to show the reliability of the system through simulation.

Electricity: In Scenario One, the electrical production (based on regional renewable sources without including fuel burning power plants) amounts to about 94% of the demand requirements. Taking fuel burning power plants into account, the electrical production of Scenario One supplies 122% of demand. This includes the surpluses that are used for hydrogen production. Any fluctuations in electricity production can be fully compensated by a combination of renewable energy technologies and an intelligent control and exchange structure. Energy supply is shown to be as reliable as with any conventional system. The other scenarios have a higher surplus. Solar-thermal plants are employed in Scenarios Five and Six for the supply of electricity for hydrogen production.

Heat: The combination of solar collectors and cogeneration plants utilised in Scenario One can cover the demand for low temperature heat in the industrial sector as well as in the commercial and residential sector. The gross heat production of solar-thermal systems in these sectors slightly exceed heat demand but heat losses due to storage and transport of heat mean that more heat has to be supplied by small cogeneration systems. The resulting total heat production amounts to 119% of the heat demand. The share of solar produced low temperature heat in the industrial sector is about 92% of requirements.

Steam turbines used in industrial cogeneration can produce about 30% of the industrial demand for high temperature heat. Fuels from renewable sources supply the deficit.

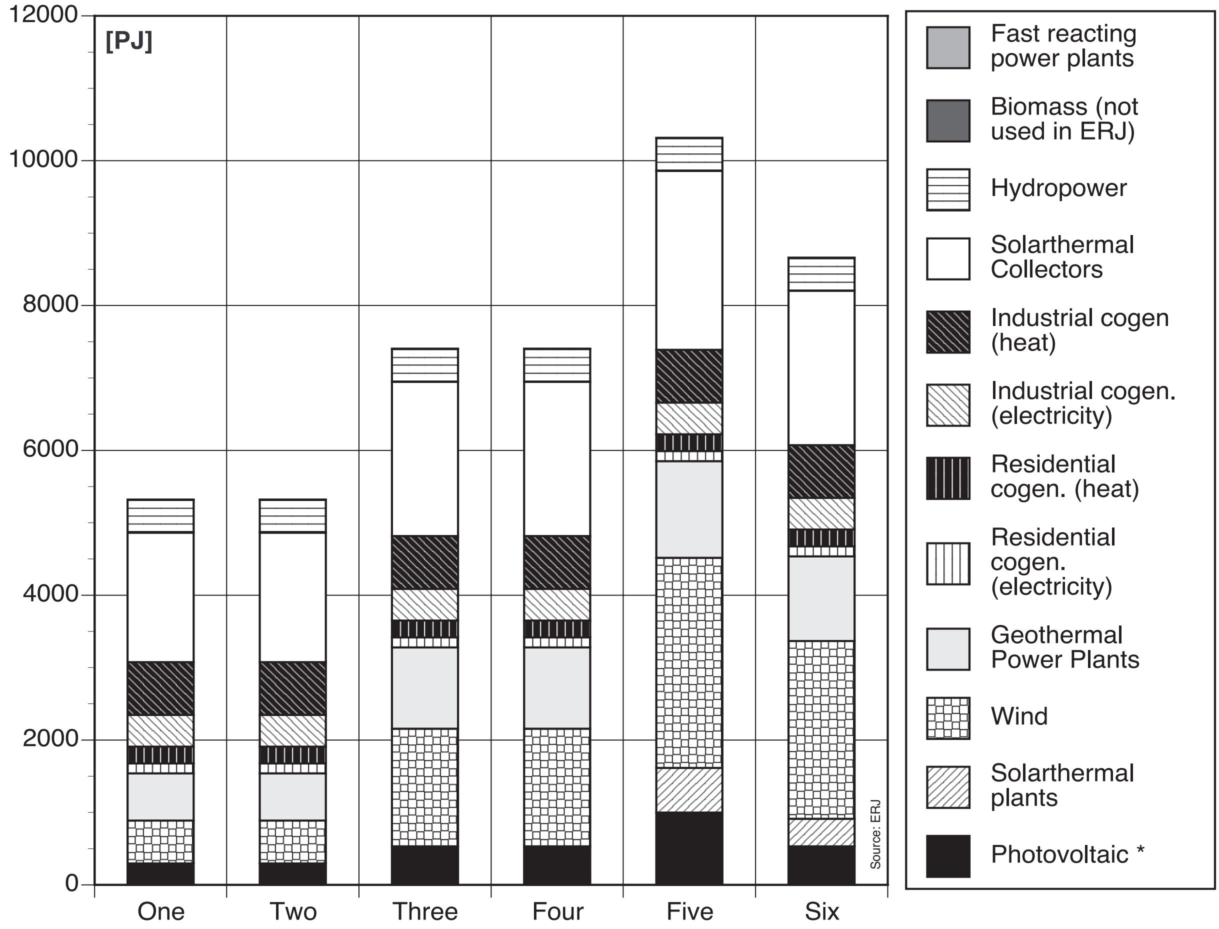
Fuels: The fuel demand for heat and electricity production of cogeneration plants in Scenario One is 1,920 PJ, of which about 370 PJ of hydrogen is produced by the supply system itself, leaving the rest to be supplied from other sources. About 1,980 PJ is required for the production of high temperature heat in the industrial sector and approximately 1,180 PJ is needed for transport.

Altogether about 4,700 PJ of hydrogen equivalent fuel remains to be produced from other sources in Scenario One. Hydrogen can be produced by the increased use of domestic renewable sources, such as wind power, photovoltaics and solar power plants as discussed in the scenarios in the supply chapter

In Scenario One the electrical output of photovoltaics, wind power, hydropower and geothermal energy supplies about 48% of the primary energy production. Solar-thermal collectors produce an additional 14%. Renewable fuels account for about 38% of primary energy production; this includes three percent of the primary energy that comes from domestic hydrogen production.

The amount of fuels imported in Scenario One represents 20% of the amount of energy imported into Japan in 1999.

The diagram below shows the percentage of regional sources compared to imports in the scenarios. Scenario One is the scenario described in detail in this report, whereas Scenarios Five and Six both show a 100% regional energy supply for Japan.



Note: This is the production of electricity and heat in the installed power plants. Biomass is set to zero. Sustainably produced biomass holds enormous potential, but the amount available was unknown at the time of publication of this study.

Figure 54 : Domestic energy production in all "Energy-Rich Japan" scenarios

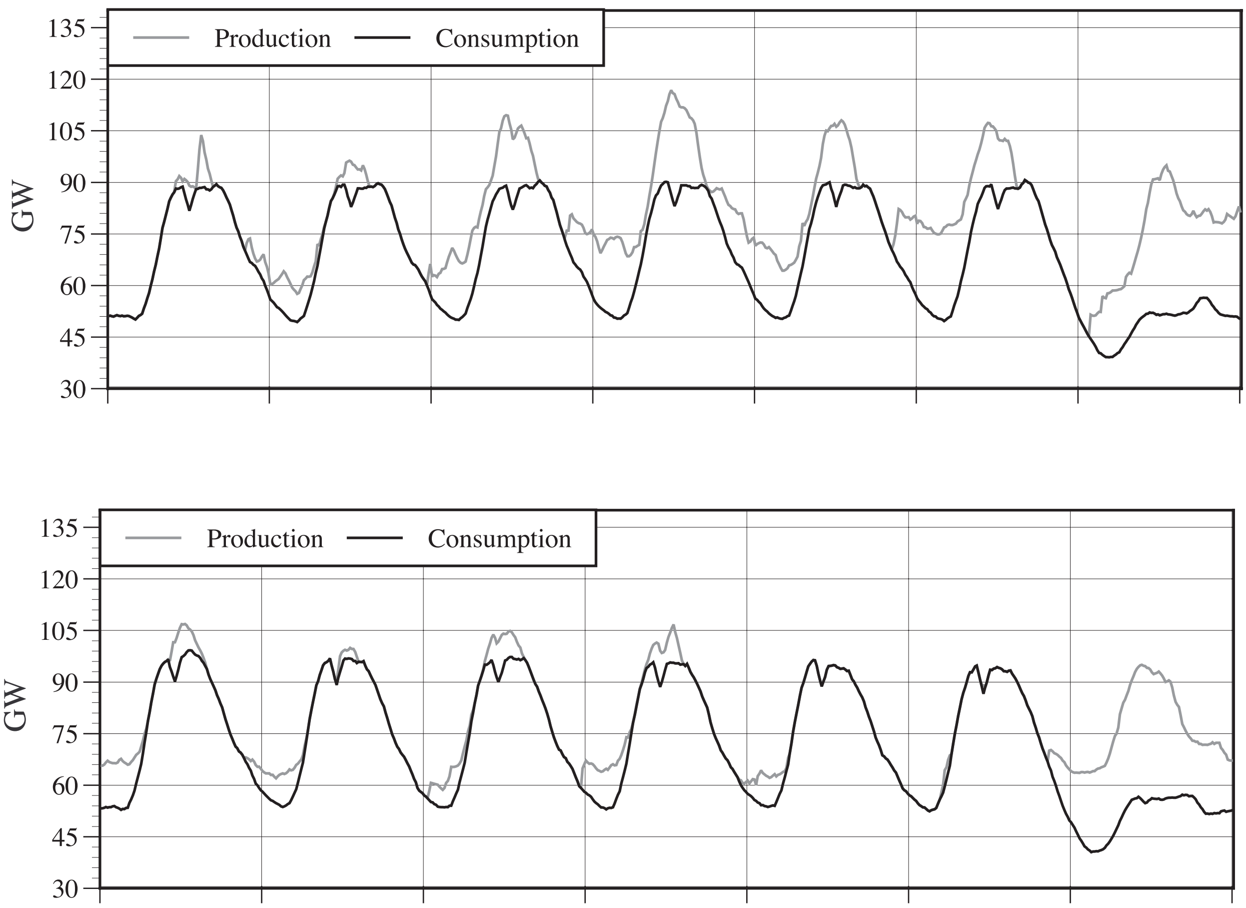
7.3) Simulation

Japan was divided into 12 regions, which were supplied by information from 153 weather stations across the country. Using the SimRen simulation with a 15-minute resolution, it was proved that Japan is able to reliably cover its whole electrical energy demand throughout the year using domestically available renewable energy sources as described in *ERJ Supply Model* 1. The other scenarios have and use more energy and are therefore more reliable.

Fast reacting power plants and pumped storage power plants have the least full load hours, as they are only used when the other technologies cannot cover the energy demand. Wind turbines and cogeneration in the commercial and residential sectors have low full load hours compared with the other technologies because they are not adjustable and depend on wind speed and outside temperatures.

The highest electricity production from wind turbines was on the 9th of January. On that day wind turbines had a power output of 49 Gigawatts, which is 86% of the installed power. Because of the low temperatures, the maximum output of the cogeneration power plants in the residential and commercial sector of 9.8 GigaWatts was on February 4th, while in August the output of these plants was only 2.5 GigaWatts due to the high temperatures in this month.

Pumped storage plants and fast reacting plants run mainly in the afternoon and evening as the sun sets and photovoltaic production declines. At this time most people come home from work and need energy, which then has to be produced without photovoltaic support. Therefore the introduction of a summer time is highly recommended and was used in the simulation. The storages are filled mainly during the night and on Sundays, because the energy consumption is very low at these times.



Note that supply always meets or exceeds demand. Excess supply was used for hydrogen production or pumped water storage.

Source: ERJ.

Figure 55 : ERJ supply and demand in GigaWatts, showing the first week in January and third week in September in Scenario One