Daiwa Institute of Research

25 July 2011 (No. of pages: 16)

Power Shortage and Japan's Economy

Annual GDP loss would top Y14 tril on average under pessimistic scenario

Japanese report: 13 Jul 11

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Summary

- After establishing optimistic and pessimistic scenarios for nuclear power plant operation and the deployment of renewable energy in Japan, we found that this summer the power shortfall will be a maximum of 1.8% and 4.8% under the optimistic and pessimistic scenarios (monthly basis, nationwide), respectively. There will probably be substantial regional differences in the severity of the power shortages.

- Over the medium to longer term, power shortages will come to an end under the optimistic scenario, but will persist for some time under the pessimistic scenario. Under both scenarios, electricity supply from thermal power plants will rise (increasing fossil fuel imports). As a result, electricity prices will rise and CO2 emissions increase. The use of renewable energy will help curb CO2 emissions, but it will be necessary to cover the cost of deploying renewable energy by raising electricity prices.

- Power shortages will crimp the output of goods and services. Higher electricity prices will also increase costs to industry and individual living costs, lowering real incomes. Greater fossil fuel imports will mean a decrease in net exports. A worsening economic climate will cause unemployment to rise and prices to slump. By measuring the real GDP lost due to the adverse effects on the economy, we estimate that under the pessimistic scenario the loss will grow to Y19.2 trillion in FY15 and average more than Y14 trillion annually (2.5% of standard scenario GDP) over the 10 years from now.

- The estimates in this report do not take into consideration any initiatives taken on the demand side and represent a conservative (grim) assessment, assuming foot-dragging with respect to nuclear power generation strategy for many years to come. If this is the case, there could be some negative impact even under the optimistic scenario, and the losses would be enormous under the pessimistic scenario. Japan must urgently rebuild its electricity strategy from both a short- and long-term perspective.

Introduction

Renewed concern about electricity shortages

For the first time in 37 years, restrictions on electricity usage under Article 27 of the Electricity Business Act have been set in motion within the areas served by Tokyo Electric Power and Tohoku Electric Power[1]. Even in the wake of the Great East Japan Earthquake on 11 March, people were becoming less apprehensive about power shortages during the spring, when electricity demand is not so strong. However, now that summer—the season of highest demand in Japan—is here, people are once again becoming concerned about the effect of power shortages on business activity and everyday living.

Not only summer 2011 problem

But these concerns are not only about this summer. On the demand side, there are still users who have not had to make major cutbacks, and on the supply side, there are still generation facilities that could be put into service. Therefore, it is highly likely that widespread blackouts—something that must be avoided at all costs—will not occur. If anything, strains in supply-demand conditions will emerge again in winter 2011 and summer 2012, if operators keep shutting down nuclear power plants.

Number of nuclear reactors in operation already reduced to 30%

Nuclear reactors must undergo a routine inspection at least once every 13 months, pursuant to Article 54 of the Electricity Business Act and Ministry of Economy, Trade and Industry directives. Even when nothing unusual is uncovered in these inspections it has become politically difficult to restart reactors in view of the severity of the incident at the Fukushima Daiichi nuclear power plant. It is predicted that by end-July 2011 only 17 of Japan's 54 nuclear reactors will still be operating, roughly 30% of total.

With the announcement of stress tests, no reactors may be in operation in next May

While there is debate about whether individual reactors should be restarted[2], on 11 July the government formally announced the introduction of new safety assessments (so-called stress tests) for nuclear reactors. At the time of this report, the details, schedule, and legal status of these tests were still unknown. If the nuclear reactors are not restarted after undergoing inspection, all reactors could be shut down in May 2012.

Power shortages the biggest risk for FY12

The mainstream view is that the supply chains impaired by the Great East Japan Earthquake will be restored by autumn 2011, and that Japan's economic growth will turn upwards in 2H FY11, thanks to reconstruction demand. However, there is no such thing as an industry that does not use electricity, so there are fears that power shortages will crimp output and that it will be impossible to elicit private and public sector reconstruction demand. A tight power situation could foster an atmosphere of self-restraint, dampening consumer sentiment and, in turn, having an adverse effect on the economy.

Hard to predict how situation will unfold over medium to longer term

Furthermore, there appears to be a rapidly growing awareness of the possibility that power shortage woes could have economic and societal effects over the medium to longer term. Companies that cannot obtain a consistent supply of electricity may be forced to reconsider the location of their manufacturing facilities. The public will

1. Regulations mandate that commercial-scale utility customers (more than 500 kW contracts) reduce electricity consumption this summer by 15% from maximum electricity consumption last summer. The restriction applies from 1 July to 9 September in areas served by Tohoku Electric Power and from 1 July to 22 September in areas served by Tokyo Electric Power. Intentional violation of the restrictions, even by one hour, will be penalized.
2. At the beginning of July, there was growing momentum to restart the Genkai nuclear power plant located in Saga Prefecture, with the consent of local authorities. However, on 6 July, Prime Minister Naoto Kan suddenly announced the implementation of so-called stress tests for all nuclear reactors, and also on 6 July there was discussion in the Diet about improprieties surrounding a TV program that was debating whether the nuclear plant should resume operations. As a result, it appears likely that restarting the plant will be postponed. (After release of this report, a decision was made not to resume operation of the plant.)

be forced to change their way of thinking about electricity and energy, which could influence national policy. Overhauling energy/electricity policy is an urgent task in the wake of the nuclear crisis that resulted from the Great East Japan Earthquake, but amid the political turmoil it is hard to predict how the problem of electricity shortages will unfold in either the short term or in the medium to longer term.

1. Optimistic and Pessimistic Scenarios

Two electricity supply scenarios

In this report, we estimate the short- and medium- to longer-term economic impact of power shortages. Our estimates cover the timeframe beginning in FY11 and ending in FY20. To begin, we established an optimistic scenario and a pessimistic scenario for electricity supply, so that we could consider the potential scale of future power shortages. Then, we defined the gap between this supply and conceivable demand as the shortage.

1.1 Optimistic scenario

Optimistic scenario a realistic one

First, we outline assumptions used in the optimistic scenario. The optimistic scenario assumes that there is a sound supply framework for each source of electricity, but it is nevertheless a realistic scenario in that it is not overly optimistic about nuclear strategy, fossil fuel prices, or the cost of deploying renewable energy.

Nuclear reactors will be restarted

In this scenario, we assume that the nuclear reactors that are currently undergoing routine inspection will be restarted from July onward following the post-inspection run. This scenario also assumes that the Onagawa nuclear power plant (reactors 1-3) and the Kashiwazaki-Kariwa nuclear power plant (reactors 2-4), which have been shut down due to the Great East Japan Earthquake and other issues, will resume operation in January 2013.

Nuclear power strategy at a standstill

However, this scenario also assumes that, at minimum, Fukushima Daiichi reactors 1-4 will be decommissioned as planned, and that the Fukushima Daini plant, which is in the evacuation zone, and the Hamaoka nuclear power plant, which was shut down at the request of Prime Minister Naoto Kan, will not be operational. Furthermore, this scenario assumes that Japan's nuclear strategy will remain at a standstill for the next 10 years, and no new nuclear power plants will be built, and projects already begun will not be completed. It is assumed that the nuclear reactors that will reach the end of their design life (40 years from start of operation) in the years up to FY20 will follow the decommissioning process according to schedule[3]. While this is something that will be debated as part of Japan's nuclear strategy, in this report we are seeking to conservatively gauge the effects of power shortages, so we based even our optimistic scenario on this assumption.

For now, realistic to address the issue with traditionally reliable thermal power

Raising thermal power operating rates will probably be adopted as a strategy to compensate for the supply shortages caused by the nuclear shutdowns. With Japan in the midst of a power emergency, it will have to temporarily set aside concerns about CO2 emissions, after fully explaining the situation to the international community[4]. There have been a variety of advances in thermal power technology, and it is claimed that such advances have given rise to means of generating power with lower CO2 emissions. The estimates in this report take into account both the expansion of thermal facilities that was planned before the Great East Japan Earthquake as well as the post-earthquake increase in capacity.

3. As a result, 29 nuclear reactors will be operating as of end-FY20.
4. It is natural to think that Japan, as an energy-saving industrialized country that has experienced a nuclear power plant incident that had various impacts worldwide, will provide an honest account to the international community. It would be something of a problem if Japan's explanation were insufficient and Japan found itself stuck on the CO2 issue even in a time of emergency.

Thermal power operating rate to be raised an average 25 pp to 80%, and up to 92% at peak times

Before the earthquake, the national average operating rate for thermal power was about 55%[5]. This scenario assumes that, depending on demand for power, the average operating rate will be increased to 80% (70% for LNG, 85% for coal, and 90% for oil), and that at peak demand times the marginal operating rate will be boosted to the 92% that is seen as an upper limit for a stable supply (8% reserve capacity). Based on generation cost, the order in which thermal power is used to replace nuclear power is coal, LNG, and then oil. Based on expanding global demand for resources, we assume that fossil fuel prices will rise some 20% by FY20.

Assuming government vision for renewable energy to be realized 10 years early

This scenario assumes that the government's pre-earthquake goals for power generation from renewable energy sources such as solar power and wind power, originally planned for FY30, are achieved 10 years earlier in FY20. The Strategic Energy Plan approved by the cabinet in June 2010 calls for Japan to increase the proportion of energy generated from renewable energy sources, such as hydropower, to 21% by FY30, with 12% to come from new energy technologies (solar power and wind power). The comparable figures for FY07 were 8.6% and 1.0%. To achieve this, Japan would have to achieve a 2.4-fold increase in renewable energy power generation capacity (16.9-fold increase in new energy capacity), which is itself an ambitious goal. But this scenario assumes that there will be a faster push to realize these goals by mobilizing a variety of resources, including massive investment.

Assumptions regarding solar power

It is currently fairly expensive to generate electricity from solar power, but this scenario presumes that construction costs will decline due to technological advances and increased volume. It assumes that the average feed-in tariff (which directly increases electricity prices) will be lowered by Y2.5 each year from the current Y41/kWh (Y42/kWh for residential and Y40/kWh for non-residential) until it is about half the current level in FY20. At the same time, investment in renewable energy facilities/equipment by households and businesses will create jobs and income, so our estimates take into account such positive effects.

1.2 Pessimistic scenario

Conceivable pessimistic scenario

Next we outline the assumptions used in the pessimistic scenario. Even if the above optimistic scenario is grounded in reality, it is still an optimistic scenario. Although we would rather want that it was not the case, for now we believe this pessimistic scenario could become a reality.

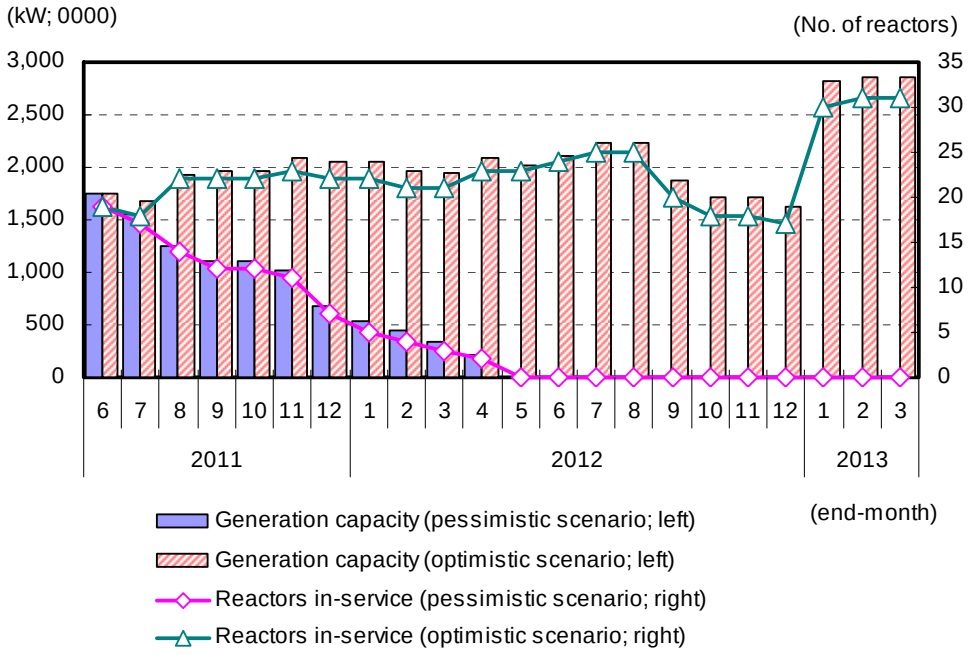
Complete nuclear power plant shutdown

This scenario assumes that in addition to the Fukushima Daini plant, which is within the evacuation zone of the Fukushima Daiichi plant incident, all nuclear reactors will be shut down in the wake of routine inspections. As shown in Chart 1, this means that no electricity will be generated from nuclear reactors by May 2012.

5. FY07 actual operating rates were 79.4% for coal, 55.9% for LNG, and 33.0% for oil.

Nuclear Power Generation: Optimistic and Pessimistic Scenarios Chart 1

If nuclear power plants under regularly scheduled inspection unable to resume operations, no supply of nuclear power expected from spring 2012



Source: Compiled by DIR based on media reports.

Comparison of Optimistic and Pessimistic Scenarios on Electricity Supply Chart 2

	Optimistic scenario	Pessimistic scenario
Nuclear power	* Facilities currently undergoing routine inspection will be restarted in turn beginning July 2011 following the post-inspection run. *Facilities that were temporarily shut down due to the earthquake or other problems will be restarted in January 2013. * The Fukushima Daiichi, Daini, and Hamaoka plants will not become operational. No new nuclear power stations will be built, and those already begun will not be completed. *Reactors will be decommissioned 40 years after start of operation.	* No reactors will be restarted, including those currently undergoing routine inspection. * In May 2012, there will be no power generated from nuclear reactors.
Thermal power	* To meet the demand for power, operating rates will immediately be boosted significantly (with the operating rate at peak times to be raised to 92%). * Power supply to increase in line with completion of pre-earthquake planned construction and recent expansion. * However, in FY20 prices for crude oil, LNG, and coal will be 20% higher than the current level.	* Operating approval for thermal power facilities will not be given quickly, so the amount of power will increase only gradually up to end-2012. * Same as the optimistic scenario for 2013 and beyond.
Renewable energy	* The government goal of having 21% of power generated from these sources by FY30 will be achieved by FY20. * The feed-in tariff (cost) of solar power will decline to about half the current rate by FY20 thanks to technological innovation and upscaling.	* Deployed at the scale planned by power producers before the Great East Japan Earthquake (10% or less of the optimistic scenario, as of FY20). * There will be little technological innovation in solar power, and feed-in tariffs and construction costs will remain constant until FY20.

Source: Compiled by DIR.

Assumes that the approval process for expanding output from thermal power stations will be slow

While the optimistic scenario assumes that thermal power operating rates will immediately be increased, the pessimistic scenario assumes that the government will be slow to grant approval and power output will rise only gradually up to end-2012. In other words, compared to the optimistic scenario, this scenario sees much less power being supplied from thermal sources in 2011-12. It is entirely possible that it will be impossible to hike output from thermal power sources amid battles over issues such as CO2 emissions and restarting nuclear reactors.

Thermal power supply will be the same as the optimistic scenario for FY13 and beyond

However, with nuclear plants shut down it is hard to imagine the government refusing to approve increases in output from thermal facilities over the medium to longer term. Therefore, even this scenario assumes that from 2013 onwards the same amount of power will be supplied from thermal facilities as under the optimistic scenario.

Limited renewable energy supply at only 10% or less of optimistic scenario

The pessimistic scenario assumes that up to FY20, renewable energy will be deployed at the same pace as shown in the FY10 electricity supply plan overview (Mar 2010, Agency for Natural Resources and Energy)[6]. This is the scenario envisaged by the power producers before the earthquake, meaning that renewable energy capacity would be 10% or less of the optimistic scenario.

1.3 Scale of power shortages

Average electricity demand for past seven years extrapolated

Electricity demand is affected by the economic climate, but we assume that consumption will be flat from the FY04-10 average. This timeframe includes the time around the financial crisis induced by the Lehman shock, so by taking the average for this period it is fair to say that we are neither under-estimating nor over-estimating demand.

Calculation assumes that electricity demand remains constant, making it conservative

Of course, electricity saving measures will probably be instituted and efforts made to curtail demand during high-demand periods this year and next. And, with the added incentive of the tight supply situation, there will also probably be advances in power-saving technology on the demand side in the years up to FY20. While such mechanisms should not be ignored, the aim of this report is to conservatively assess the effects of power shortages, so we based our calculations on the assumption that demand will remain unchanged.

Compiled by month and region

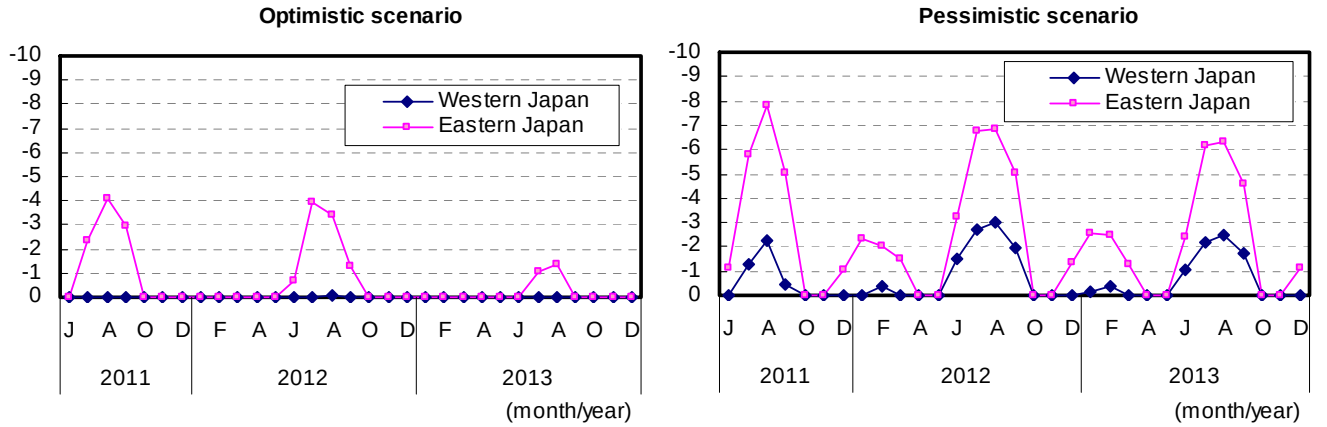
Even if electricity demand is given on a fiscal-year basis, there are fluctuations in demand during a year. Additionally, there are physical and technical issues involved in sharing electricity among power producers. Thus, for the two scenarios that we have already discussed, we calculated the power shortfalls by power producer regions on a monthly basis taking into consideration power obtained from other companies. Then, we determined the months seeing power shortfalls and the volume of shortfall for each respective month. Specifically, we defined months with power shortfalls as those where the supply shortfall occurs for 12 hours a day on 20 business days. Here, supply shortfall is the difference between near peak demand and maximum supply after taking the safety margin into consideration. The shortfall is assumed to be zero in months and regions where near peak demand does not exceed supply.

6. The electricity supply plan overview (Japanese available, “Denryoku kyokyu keikaku no gaiyo”) shows annual plans from FY10 to FY19 but not a clear timeframe from FY20 onwards. In this report we assumed that business plans for FY20 and beyond would be simultaneously executed in FY20.

Short term: Eastern Japan will experience summer shortages even under the optimistic scenario

Charts 3 and 4 show monthly power shortage rates (shortfall as a percentage of power demand) for eastern Japan and western Japan[7]. Under the optimistic scenario (left graph, Chart 3), eastern Japan will experience power shortages in the summer for the next two years[8]. This means that Tokyo Electric Power will not be able to replace the capacity lost from the nuclear power plants that stopped operation after the quake with power from other sources. On a nationwide basis (excluding Okinawa Prefecture), the shortage will peak at 1.8% in August 2011.

Power Shortage Ratio: Short Term (%) **Chart 3**



Source: Ministry of Economy, Trade, and Industry; compiled by DIR.

Short term: Major power shortages, with regional differences, under the pessimistic scenario

Under the pessimistic scenario (right graph, Chart 3), all power producers would experience shortages in their respective regions in summer 2011, and these shortages would be substantial. Some power producers would also see shortages in winter 2011. In western Japan, the shortages in the summer of 2012 and 2013 would be worse than those in summer 2011. Under the pessimistic scenario, there would be fairly significant differences in the power shortages in each region, depending on nuclear power dependency, timing of nuclear shutdowns, and power demand seasonality. On a nationwide basis (excluding Okinawa Prefecture), the shortage will peak at 4.8% (in August 2011).

Long term: Power shortages will be resolved under the optimistic scenario

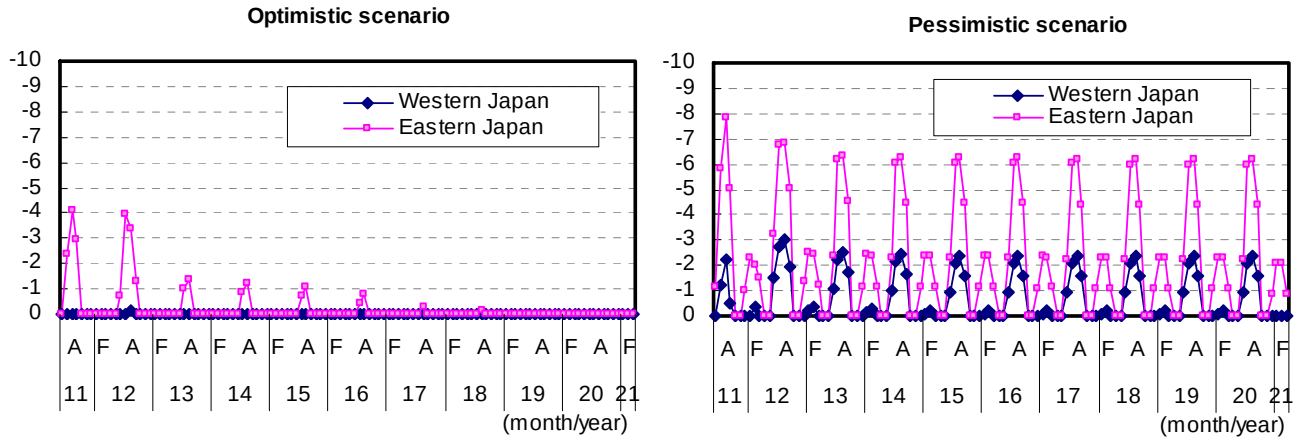
Under the optimistic scenario (left graph, Chart 4), over the medium to longer term the power shortages will gradually narrow and eventually come to an end. Even assuming that nuclear reactors are decommissioned when they reach the end of their useful life, some reactors will keep operating, and renewable energy will be increasingly exploited along with rising operating rates for thermal power facilities.

Long term: No end in sight for power shortages under the pessimistic scenario

On the other hand, under the pessimistic scenario, in which little progress is made towards adopting renewable energy sources, there will continue to be sizeable power shortages every summer and winter. With almost no power being supplied from nuclear facilities, thermal power will be used to the maximum, but there will be no prospects for seeing an end to power shortages. It is hard to imagine that this is a realistic long-term scenario, but the potential magnitude of the problem is understood.

7. Major power company (excl. Okinawa) basis. We aggregated data for eastern Japan based on power producers of 50 Hz frequency and western Japan based on those of 60 Hz frequency (small areas with mixed frequencies covered by Chubu Electric Power included in western Japan).
8. As already mentioned, we extrapolated power demand by the historical average. Thus, if there is a reduction in power usage matching the power shortage on the demand side, power shortages would not occur. However, even in that case the potential for power shortages should still be acknowledged.

Power Shortage Ratio: Medium to Long Term (%) **Chart 4**



Source: Ministry of Economy, Trade, and Industry; compiled by DIR.
Notes: 1) Major power company (excl. Okinawa) basis.
2) Power shortage ratio: ratio of power shortage to demand; demand: FY04-10 avg power consumption (excl. effects of energy-saving technology/management).

2. Generation Costs, Electricity Prices, and CO2 Emissions

Eliminating power shortages and costs are separate issues

Even if power shortages disappear over the longer term under the optimistic scenario, this scenario assumes a big increase in operating rates for thermal power facilities and a massive expansion of renewable energy, which would entail various costs[9]. Therefore, we will examine what will happen to the cost of electricity generation, electricity prices, and CO2 emissions under the above scenarios.

2.1 Generation costs

More than Y4 tril costs each year under the pessimistic scenario

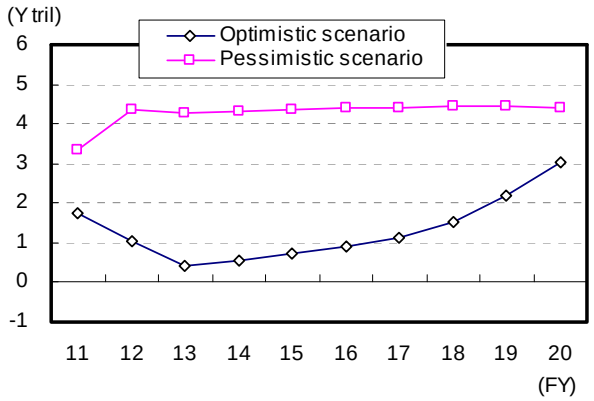
As shown in Chart 5, from a macro point of view, annual generation costs (fuel cost, power plant operating cost, etc.) will range from hundreds of billions of yen to Y3 trillion under the optimistic scenario and rise to more than Y4 trillion under the pessimistic scenario. Under the pessimistic scenario, continuing sizeable imports of fossil fuels will have a major effect on costs.

Cost of adopting renewable energy the biggest cost under the optimistic scenario

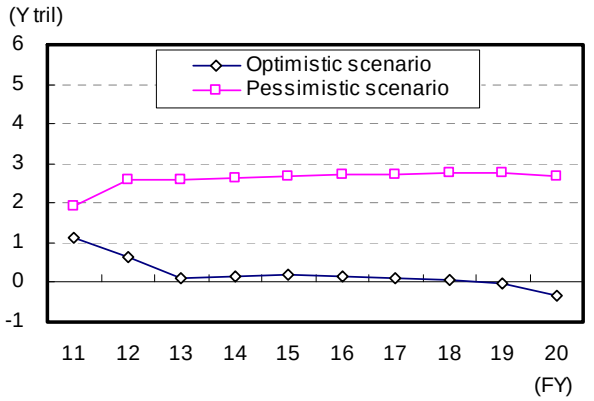
On the other hand, under the optimistic scenario the fuel costs associated with thermal power will decline as nuclear power operating rates rise toward FY13 (charts 1 and 6), but after that the cost of implementing renewable energy will rise. In order to ensure that renewable energy becomes as widespread as envisaged in the optimistic scenario it will probably be necessary to cover the cost by placing a surcharge on electricity prices (borne by the consumer) through a feed-in tariff scheme, or by having the government subsidize the cost (borne by the taxpayer). As explained earlier, this scenario assumes that the cost of solar power will decline thanks to technological advances, so, if this does not happen, generating costs will rise even more.

9. This brings up the question of how to gauge the reduction in costs from shutting down nuclear power plants. However, in view of the fact that it will be necessary to maintain these facilities for the time being even if they are shut down, the fact that there are decommissioning costs if reactors are decommissioned, and the fact that compensatory costs associated with the Fukushima Daiichi nuclear plant incident are expected to be enormous, in this report we did not take into account any cost reduction from a decline in nuclear power generation.

Power Generation Costs **Chart 5**



Fuel Costs **Chart 6**



Source: Compiled by DIR based on various statistics.

2.2 Electricity prices

Generation costs reflected in electricity prices

These generating costs come back in the form of higher electricity prices, which are borne by households and businesses. Assuming that the increased costs are allocated equally to households and businesses, this would mean a big increase in commercial power prices, which are fairly low.

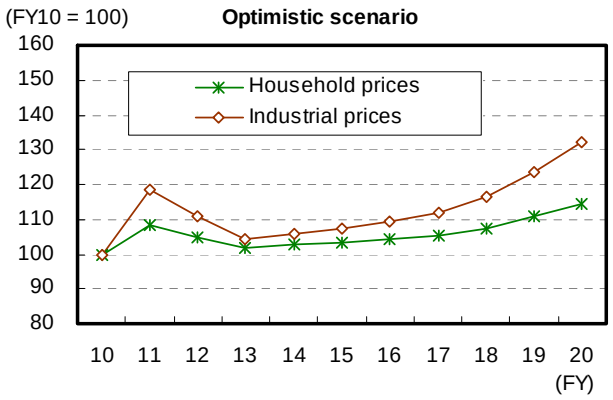
Optimistic scenario: Gradual rise in electricity prices

Under the optimistic scenario (Chart 7), electricity prices would initially rise as thermal power is used to cover the shortfall caused by nuclear power plant shutdowns, but later electricity prices would temporarily fall back as nuclear reactors are restarted. However, electricity prices would begin rising again in the latter part of this decade as renewable energy is implemented on a big scale.

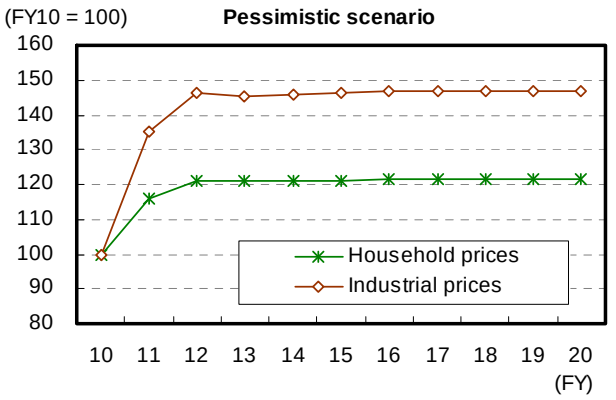
Pessimistic scenario: Electricity prices would immediately rise and then remain high

On the other hand, under the pessimistic scenario (Chart 8) the increased generation costs from using thermal power as a replacement energy source would cause residential-use power prices to rise some 20% and commercial-use power prices to rise nearly 50% from their 2010 levels. Because operating rates will be boosted at not only coal- and LNG-fueled power plants, but also at relatively expensive oil-fueled power plants, electricity prices will remain high, pushing up both industrial costs and living costs in Japan.

Electricity Prices to Rise Gradually **Chart 7**



Electricity Prices to Remain High **Chart 8**



Source: Compiled by DIR based on various statistics.

2.3 CO2 emissions

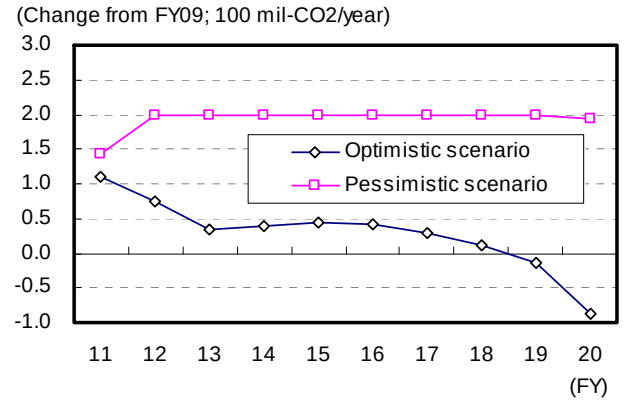
CO2 emissions will fall considerably under the optimistic scenario

As shown in Chart 9, there is a sizeable gap in CO2 emissions between the optimistic and pessimistic scenarios. Under the optimistic scenario, an increase in operating rates at thermal power facilities will temporarily give rise to additional CO2 emissions. However, emissions will subsequently gradually decline, and by FY20 emissions may even be 100 million tons lower (compared to FY09) thanks to the restarting of nuclear reactors and major advances in the implementation of renewable energy. In FY09 emissions were 1,145 billion tons, so the reduction in FY20 would be equivalent to 7.6% of FY09 emissions. While it is important to remember that this will be at the expense of higher electricity prices, if we consider only CO2 emissions, the effects of deploying renewable energy will be substantial.

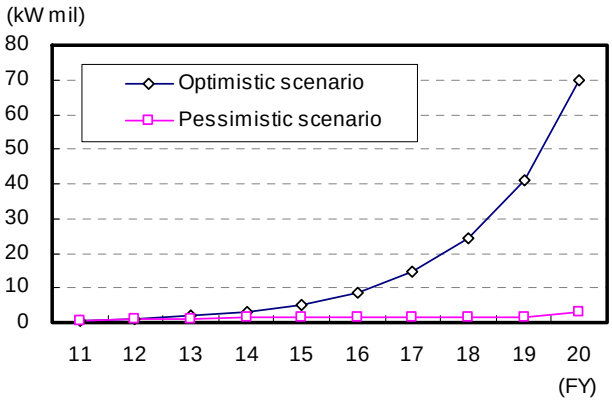
CO2 emissions remain high under the pessimistic scenario

On the other hand, this kind of reduction in CO2 emissions is not seen under the pessimistic scenario, since it assumes that renewable energy deployment will be extremely limited, as shown in Chart 10. As dependency on thermal power grows, CO2 emissions will remain at a level that is 150-200 million tons higher than the current level.

CO2 Emission from Thermal Power Generation **Chart 9**



Generation Capacity from Renewable Energy **Chart 10**



Source: Compiled by DIR based on various statistics.

3. Estimation of Macroeconomic Impact

Power supply and demand will be balanced at the cost of foregone income

So what would be the impact of power shortages on the Japanese economy under these optimistic and pessimistic scenarios? With electricity in short supply relative to demand, supply and demand will be balanced by curtailing prodution activity, indicating that businesses and households will lose the income they would have generated from this activity. At the same time, higher electricity prices will push up costs to industry and individual living costs, lowering real incomes. If incomes decline, consumption and investment will also shrink, which in turn will lower the standard of living. However, the investment in renewable energy will represent new demand.

Macroeconomic-estimate concept

In this report, we are primarily considering the economic impact from the demand side. We estimated the macroeconomic impact of power shortages in terms of 1) the direct decline in real GDP due to power shortages, 2) the increase in investment in order to build up replacement generation capacity, and 3) the rise in electricity prices. We ran a simulation for these three exogenous factors on the DIR medium-term macroeconomic model.

3.1 Three assumptions, two scenarios

Calculation of direct decline in GDP

We estimated how much real GDP would be directly reduced due to the power shortages[10]. There are a variety of methods for estimating this, but we have used the method shown in Chart 11. First, we estimated the reduction in real GDP by region by multiplying the volume of power shortfall defined in section 1.3 by the electricity consumption rate (real GDP / power demand; FY04-08 average). Then, we aggregated regional figures to a nationwide figure. Since higher operating rates for thermal power plants will mean an increase in imported fuel, we tacked this increase in imports onto the reduction in real GDP (imports are a deduction from GDP).

Under pessimistic scenario GDP will be directly reduced by Y10 tril annually through FY20

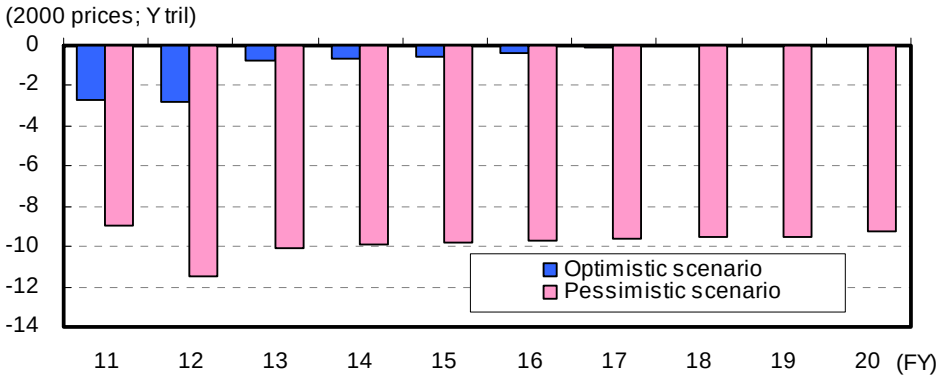
Chart 12 shows reductions in real GDP based on this method. Under the optimistic scenario real GDP is reduced by around Y3 trillion in FY11 and FY12, but it is reduced only slightly thereafter. By contrast, under the pessimistic scenario it will be reduced by about Y10 trillion each year through FY20.

Estimating Direct Impact of Power Shortage on Real GDP **Chart 11**

1. Estimate power shortfall in each region from historical average electricity demand and electricity supply under each scenario.
2. Find the historical average power consumption rate (real GDP / electricity demand) for each region.
3. Multiply the power shortfall for each region by the respective power consumption rate, and obtain the reduction in Japan's real GDP by aggregating the resulting figures.
4. Add to this the increase in fuel costs associated with higher thermal power operating rates.

Source: Compiled by DIR.

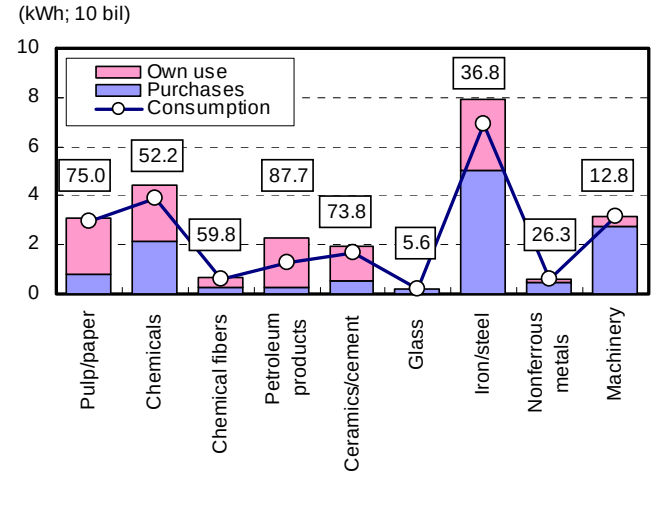
Direct Impact of Power Shortage on Real GDP **Chart 12**



Source: Compiled by DIR based on various statistics.

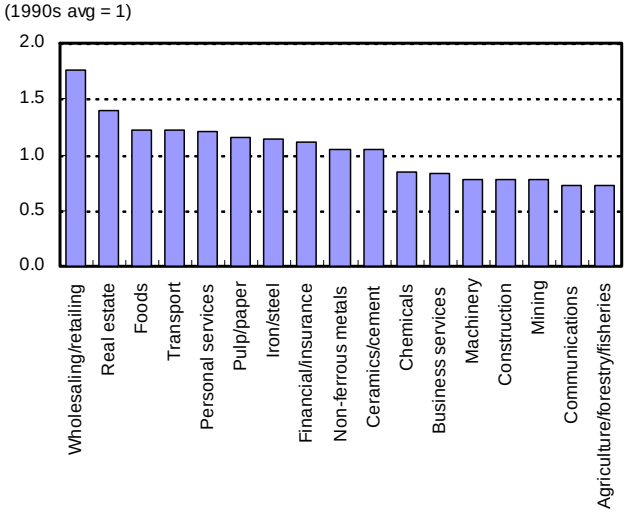
10. The reduction in real GDP calculated by the DIR medium-term macroeconomic model takes into account indirect influences that flow through the economy in the form of quantities and prices. The “direct reduction” that we calculated here is the primary reduction in GDP in the sense that production stops due to power shortages.

Power Purchases and Sales (2010) **Chart 13**



Source: Ministry of Economy, Trade, and Industry; compiled by DIR.
Notes: 1) Survey of 1,600 business facilities for respective industry.
2) Figures in boxes: ratio of power generation for own use.
3) Difference between bar graph and line graph: power sales.

Power Consumption per Real Production Unit **Chart 14**



Source: Agency for Natural Resources and Energy; compiled by DIR.
Note: Comparison of FY00-08 avg to 1990s avg.

Allocating reduction in output across GDP demand components

We allocated the reduction in real GDP to each demand component based on its share in GDP (average of previous five years), excluding imports and inventories. When there is a power shortage, there is a tendency to focus only on how this affects industries that consume large amounts of power (manufacturing). However, if the effects of power shortages are proportional to GDP share, there is also a large impact on service industries.

Uncertain impact of power shortages

In reality, it is unclear which industries will be affected by the power shortages and by how much they will be affected. Until now, the conventional assumption regarding economic activity has been that there will be an unrestricted supply of power to meet demand. Even if we know how much demand for power is induced when various goods and services are produced, we do not have a clear grasp of what goods and services will no longer be produced when electricity supply is restricted. As shown in Chart 13, many industries that are big power consumers produce much of their own power, so they may have the ability to deal with short-term chaos. At the same time, as shown in Chart 14, power consumption per unit of real output has been rising since the beginning of this century in the wholesaling/retailing, real estate, transportation, and personal services industries, and therefore power shortages could hurt these industries.

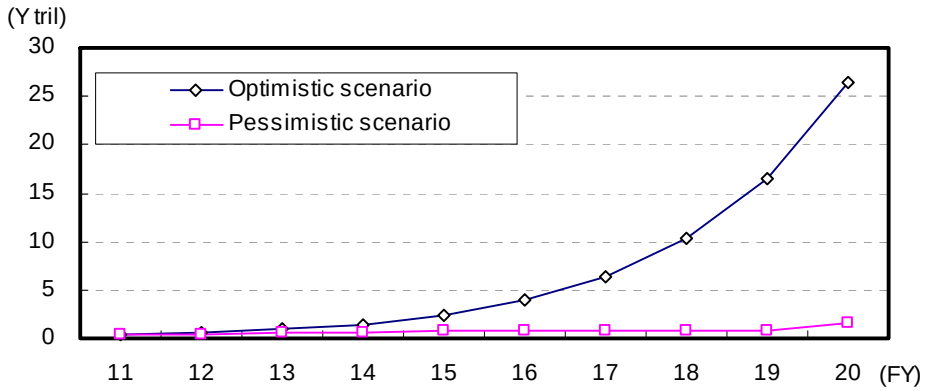
Assumptions about investment in renewable energy

Investment in replacement generation capacity is the second factor needed for our macro estimate, and we derived this from the construction cost of the assumed renewable energy capacity under each scenario (Chart 15). As we stated earlier, the pessimistic scenario assumes that there will be little progress made in the deployment of renewable energy, and therefore investment will remain at a low level even in FY20. By contrast, the optimistic scenario assumes that investment will rise all the way through FY20, and that cumulative investment over 10 years (businesses and households) will be a fairly substantial Y70 trillion or so.

Higher electricity prices

The third factor is the influence of higher electricity prices due to increased generating costs, and we estimated the portion of electricity prices that would be passed through to output prices by multiplying the increase in electricity prices (shown in charts 7 and 8) by the weighting of electricity prices in price indexes (CPI and CGPI, roughly 3%).

Installation of Renewable Energy Facilities (Businesses and Households) Chart 15



Source: Compiled by DIR based on various statistics.

3.2 Macroeconomic simulation

Simulation results

The results of simulation undertaken using the DIR macroeconomic model, based on the above assumptions, are shown in charts 16-19. The charts show differences from the standard scenario for optimistic and pessimistic scenario. The standard scenario is "Japan's Medium-term Economic Outlook: June 2011," (13 July 2011; Japanese version 16 June 2011). The results bring to light a number of points.

Pessimistic scenario has a negative 1.3 pp impact on growth in FY11 and a negative 1.1 pp impact in FY12

First, real GDP growth will remain below the standard scenario until FY14 under both the optimistic and pessimistic scenarios (Chart 16). In FY11, growth will be 0.4 points lower under the optimistic scenario and 1.3 points lower under the pessimistic scenario, and in FY12 growth will be 0.4 points lower and 1.1 points lower, respectively. If the pessimistic scenario becomes reality, Japan will experience sharp negative growth in FY11, and there will not be strong economic growth even in FY12, when reconstruction demand is expected to emerge.

Power shortages will depress incomes and prices

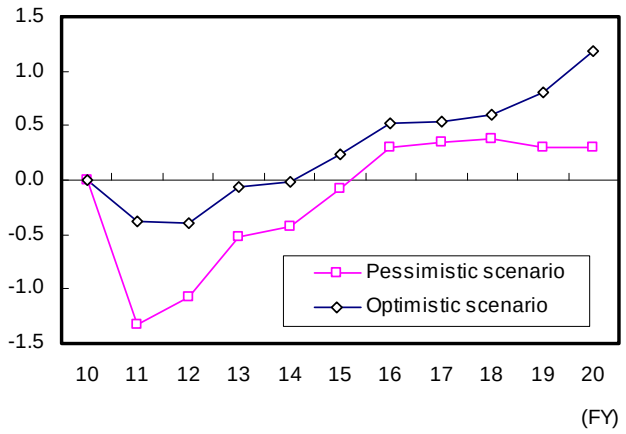
If there are power shortages, demand will slump for a few years across a wide range of categories, including consumer spending, investment, and exports. Production will also slump. Under the pessimistic scenario, we estimate that real GDP will be Y19.2 trillion lower in FY15 and that over the 10 years from now an average of more than Y14 trillion (2.5% of standard scenario GDP) in output, demand, and income will be lost on an annualized basis (Chart 17). Furthermore, according to the simulation, higher electricity prices and the current lack of room to lower short-term interest rates will accelerate the decline in output. Lower demand will cause the GDP gap to shift towards the excess supply side, putting downward pressure on prices. It is entirely possible that even as electricity prices are rising, general prices will decline as the economy worsens. In FY11, CPI will rise faster than under the standard scenario for both scenarios, but afterwards inflation under the pessimistic scenario will fall below the standard scenario over the long term (Chart 18).

Negative impact for the first few years even under optimistic scenario

So what will happen under the optimistic scenario? Under the optimistic scenario, in which there is increased investment in renewable energy, economic growth will exceed the standard scenario in FY15 (Chart 16). However, in yen terms, real GDP will not exceed the standard scenario until two years later, in FY17 (Chart 17). Even under the optimistic scenario there will be some sort of negative impact for the first few years, and this suggests that it will take a few years for the positive effects of the increased investment to be felt.

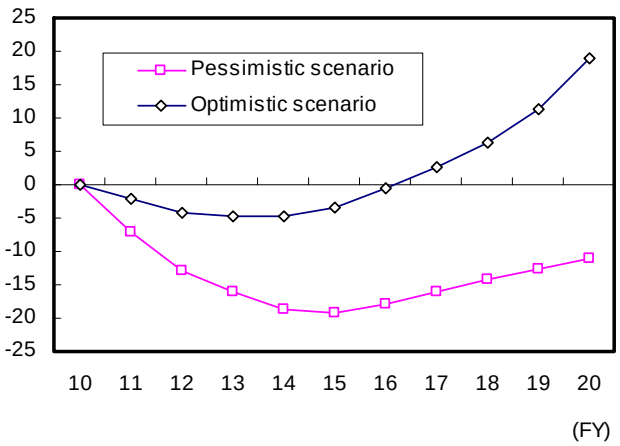
Real GDP Growth **Chart 16**

(Difference from standard scenario; % pt)



Real GDP Level **Chart 17**

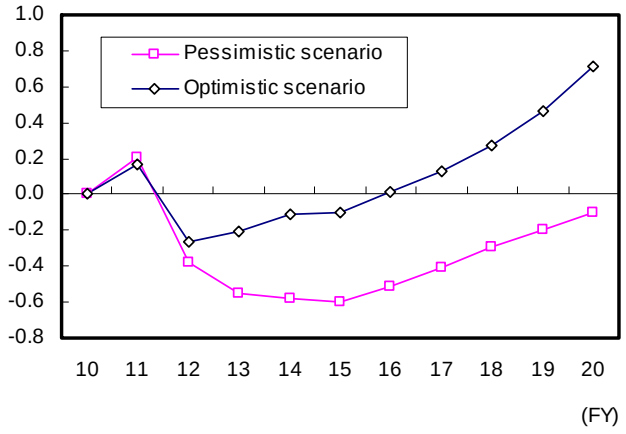
(Difference from standard scenario; Y tril)



Source: Compiled by DIR based on DIR medium-term macroeconomic model.

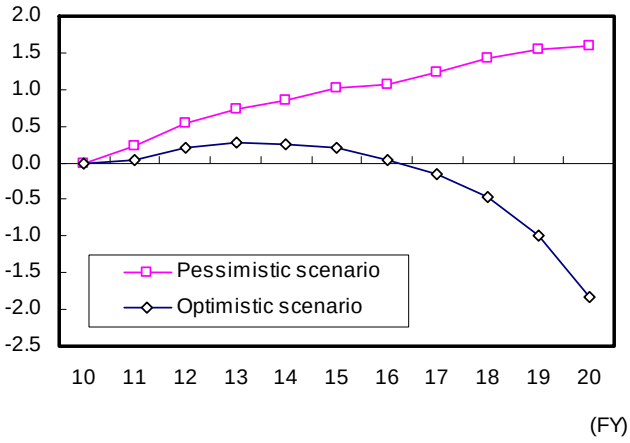
Y/y CPI **Chart 18**

(Difference from standard scenario; % pt)



Current Account Balance (% of nominal GDP) **Chart 19**

(Difference from standard scenario; % pt)



Source: Compiled by DIR based on DIR medium-term macroeconomic model.

Medium-term effect on growth, prices, and the current account

Nevertheless, in the medium term the robust investment in renewable energy under the optimistic scenario will have the effect of creating demand and employment. Under the optimistic scenario, both real GDP level and growth will ultimately surpass the standard scenario and the inflation rate will also be higher than under the standard scenario. This expanded domestic demand will gradually worsen the current account balance, and in FY20 the ratio of the current account balance to nominal GDP will be around 2 points lower than the standard scenario (Chart 19). Under the pessimistic scenario, Japan will continue to import large amounts of fossil fuels, other imports will decline due to slumping domestic demand, so the current account to GDP ratio could be higher than under the standard scenario.

Reason for near-term negative impact even under optimistic scenario

Even under the optimistic scenario there will be a negative impact for the first few years. This is because we assume that power shortages will arise even under this scenario. There may be some who object, saying that even our optimistic scenario is actually pessimistic. In this regard, as we explained earlier, this estimate takes a tough approach in that it does not take into consideration any energy-saving initiatives that may be adopted by economic agents[11]. If businesses are creative, for

11. In this respect, the pessimistic scenario stands on the same perspective.

example shifting power-use from peak to off-peak hours, economic activity could actually be maintained. Additionally, consumer spending might not decline if households used the money saved from cutting back on electricity usage for other spending and also if they bought more energy-efficient consumer electronics in order to save power, both of which could boost consumer demand. Readers should take note of the fact that this sort of positive effect is not factored into our estimates. However, the fact of the matter is that saving energy is itself a burden on businesses and households, and it will certainly put stress on the economy, even under the optimistic scenario.

Conclusion

Finally, we will briefly summarize the key points raised in this report.

After establishing optimistic and pessimistic scenarios for nuclear power plant operation and the deployment of renewable energy, we found that this summer the power shortfall would be a maximum 1.8% under the optimistic scenario and 4.8% under the pessimistic scenario (monthly basis, nationwide). There will probably be substantial regional differences in the severity of shortage.

Over the medium to long term, power shortages will come to an end under the optimistic scenario, but they will persist for some time under the pessimistic scenario. Under both scenarios, electricity generated from thermal power plants will rise (causing an increase in fossil fuel imports), and, as a result, electricity prices will rise and CO2 emissions increase. The use of renewable energy will help curb CO2 emissions, but it will be necessary to cover the cost of deploying renewable energy by raising electricity prices.

Power shortages will crimp the output of goods and services. Higher electricity prices will also increase production and living costs, lowering real income. Bigger fossil fuel imports will reduce net exports. A worsening economic climate will see a rise in unemployment and weak prices.

By simulating the adverse effects on the economy using the DIR medium-term macroeconomic model, we estimate that under the pessimistic scenario real GDP lost will grow to Y19.2 trillion in FY15, and that over the 10 years from now will average more than Y14 trillion annually (2.5% of standard scenario GDP).

Looking at the power shortage problem, including higher electricity prices, from a medium-term perspective, general prices will slump under the pessimistic scenario (in which the economy will weaken) and turn upwards under the optimistic scenario (in which investment in renewable energy will expand). Even taking into consideration fossil fuel imports for thermal power generation, the current account surplus will expand under the pessimistic scenario, but shrink under the optimistic scenario.

The estimates arrived at in this report do not take into consideration any initiatives taken on the demand side and represent a conservative (grim) assessment, assuming a foot-dragging of strategy regarding nuclear power generation for years to come. If this is the case, there could be some negative impact even under the optimistic scenario, and losses would be enormous under the pessimistic scenario.

In the New Growth Strategy released on 18 June 2010, the government named nuclear power as one of the industries in the “green innovation” arena for which there is a huge demand. The strategy listed overseas development in a pre-packaged form (including technology) as a national project, and the New Growth Strategy 2011 approved by the cabinet on 25 January 2011 cited a partnership

between Japan and Vietnam for the construction of nuclear power plants (with Japan to profit from exporting nuclear power technology, equipment, and nuclear power systems) as a visible success. There is little doubt that nuclear technology has been perceived as a wellspring of growth.

Japan's future nuclear strategy is something that must be forged through national debate, but in order to reach a consensus on a desirable energy strategy it will be necessary to weigh various factors, including timeframe, economic and social costs, and environmental burden. Even Germany, which continues to place a certain weight on renewable energy, has announced its intention to give up nuclear power and will proceed with the process of decommissioning reactors in stages through 2022. As evidenced by the hard landing envisioned from our pessimistic scenario figures, a hasty withdrawal from nuclear power would not come without problems, so we believe it necessary to realistically address and soberly discuss the electricity supply situation. Risks attaching to nuclear power cannot be ignored and all possible measures must, of course, be taken to ensure safety. Deciding overall strategy and drawing up feasible plans are pressing issues, and ones that Japan must urgently address to rebuild its energy strategy from both a short- and long-term perspective.