Building Energy Autonomy in an Era of Crisis

Surging fossil fuel costs during emergencies: Transforming energy supply and demand to avoid JPY 1 trillion in additional costs



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Table of Contents

1. Vulnerabilities exposed by the Strait of Hormuz Crisis 1
1.1 How efficiency in normalcy becomes vulnerability in emergency 1
1.2 A new direction for energy autonomy 3
2. Energy autonomy in an era of crisis 8
2.1 A way to avoid JPY 1 trillion in costs during emergencies 8
2.1.1 Designing an energy autonomy scenario: A holistic approach 8
2.1.2 Applying the energy autonomy scenario: Limiting cost increases during emergencies 9
2.2 Specifics by sector 11
2.2.1 Renewable energy: Design for new leadership and value 11
2.2.2 Nuclear power: Rethinking from cost-benefit analysis 13
2.2.3 Coal-fired power: Crisis brings forth benefits 15
2.2.4 Oil: Vehicles and resource circulation 17
3. Residual oil demand and supply chain redesign 20
3.1 The oil supply–demand structure 20
3.2 Transforming the oil supply–demand structure 23
4. Decentralized resilience through local resources 28
4.1 The value of unused local resources in normalcy and emergency 28
4.2 Local sources of biomass remain untapped 29
4.3 Local land resources that remain underutilized 31
5. Conclusions and proposals: Three policy transformations for energy autonomy 33

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1. Vulnerabilities exposed by the Strait of Hormuz Crisis

The deterioration of the situation in the Middle East since late February 2026 has made passage through the Strait of Hormuz difficult for crude oil tankers and other vessels. Japan's energy supply has consequently faced not only rising prices but also multiple constraints spanning procurement, maritime transport, and domestic refining and distribution. In 2025, Japan depended on the Middle East for 94% of its crude oil imports, and its dependence on the Strait of Hormuz[1] was 93%.[2] The crisis has exposed how a procurement structure that was efficient in normalcy can become a source of vulnerability in emergency.

We examined the rationale for Japan's increasing dependence on the Middle East. Our analysis shows that, although stockpiling and procurement diversification provide an effective buffer against short-term supply disruptions, a prolonged crisis can cause price, physical supply, and investment risks to materialize simultaneously. Preparing for such circumstances requires efforts to reduce demand, increase domestic supply, and diversify risks. And it also requires the development of *energy autonomy*: the ability to reconfigure demand, supply, and patterns of use as circumstances change.

1.1 How efficiency in normalcy becomes vulnerability in emergency

Japan's dependence on the Middle East for energy was a rational choice in normalcy. The region accounted for a large share of global crude-oil reserves and production, and extraction costs were relatively low. Japan developed a system integrating long-standing relationships with oil-producing countries, long-term contracts, maritime transport, receiving terminals, and refining facilities, establishing a framework for procuring the volumes it needed reliably and efficiently.

At the same time, domestic refineries have optimized their facilities for the properties of Middle Eastern crude oil. Even when changing crude-oil suppliers, substitution is not straightforward once supply volumes, quality, transport distance, compatibility with stockpiles, and suitability for refinery processing are considered together. Dependence on the Middle East was a rational choice for Japan in terms of both price and supply stability, despite the geopolitical risks involved (Figure 1-1).

[1] The Strait of Hormuz dependence rate is the share of Japan's crude oil imports originating from countries that rely on the Strait for shipment

[2] Ministry of Economy, Trade and Industry, "Efforts to Ensure Stable Supplies of Fuel Oil and Petroleum Products in Light of the Middle East Situation" (中東情勢を踏まえた燃料油・石油製品の安定供給確保に向けた取組等について; in Japanese) (August 2026). https://www.meti.go.jp/shingikai/sankoshin/sokai/pdf/035_02_00.pdf (accessed September 7, 2026)

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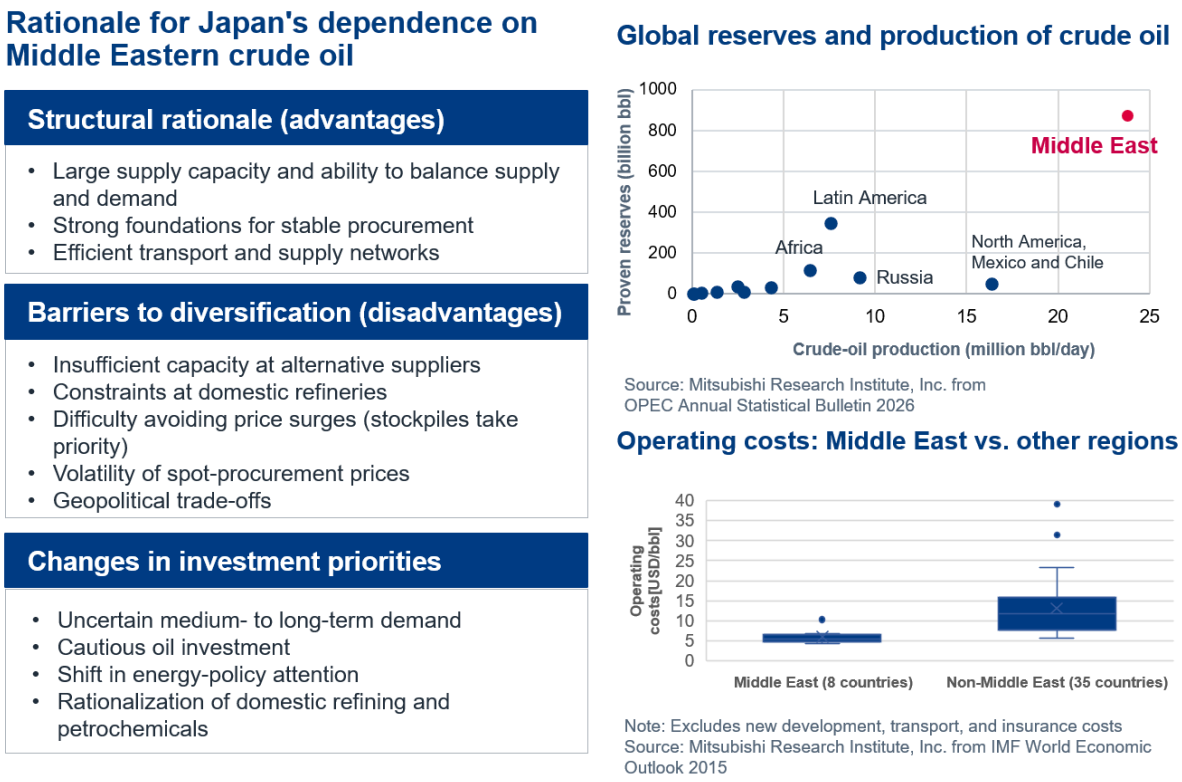


Figure 1-1 Rationale for Japan's dependence on Middle Eastern crude oil

Source: Mitsubishi Research Institute, Inc.

However, a system optimized for normalcy becomes a weakness in emergency, giving rise to multiple, interconnected risks. The effects are transmitted primarily through three channels (Figure 1-2).

Through the price channel, procurement costs rise, including maritime freight and insurance premiums. These increases feed through, with a time lag, wholesale prices, prices between businesses, and costs borne by end users. Moreover, switching procurement away from the Middle East does not insulate buyers from rising international prices for crude oil. The prices of crude oil procured from diversified, non-Middle Eastern sources also rise in line with international benchmarks and tight supply–demand conditions. Diversification therefore cannot entirely avert price surges, even when physical supply volumes are secured.

Through the physical supply channel, the concentration of supply sources is compounded by potential bottlenecks in shipping, ports, refineries, and transport and sales networks. Even when aggregate volumes are secured, the required petroleum products may not reach the places where they are needed.

Through the uncertainty channel, an increasingly unclear outlook may make companies more cautious about long-term contracts and capital investment, potentially delaying the securing of supply capacity. A crisis should not, however, be assumed to reduce all capital investment uniformly. Many companies are diversifying their overseas suppliers, changing both the composition of investment and the allocation of funds.[3]

These three channels are interconnected. Surging prices increase working capital

[3] Development Bank of Japan, "FY2026 Survey of Planned Capital Spending" (2026 年度 設備投資計画調査; in Japanese). https://www.dbj.jp/investigate/equip/national/pdf/2026_full.pdf (accessed September 7, 2026)

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requirements, while supply concerns encourage precautionary inventory accumulation and purchasing. Greater uncertainty also worsens contractual terms and investment economics, delaying the recovery of supply capacity. Through these interactions, the effects on prices and corporate costs may persist for some time, even after physical supply has recovered.

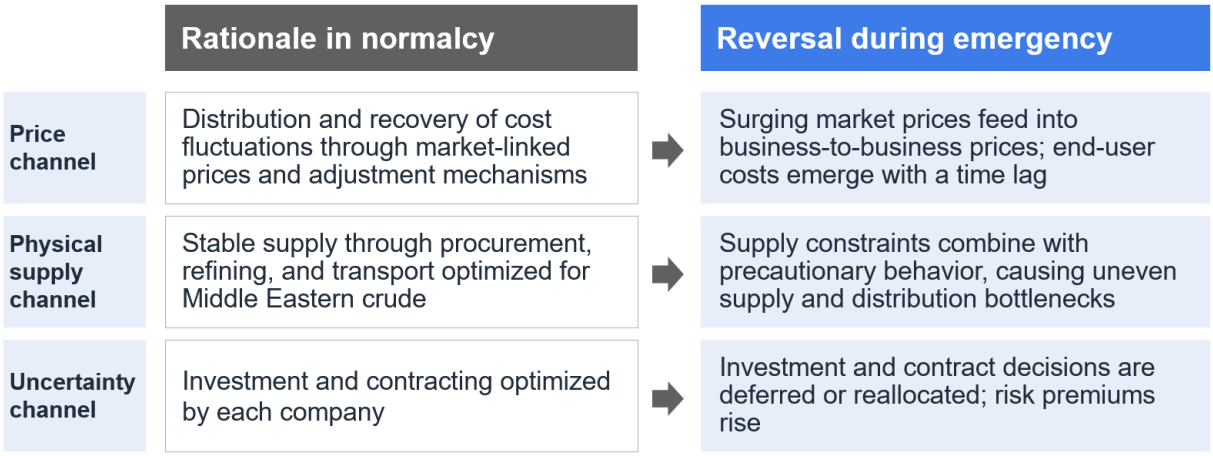


Figure 1-2 Channels through which instability in the Middle East transmits its effects

Source: Mitsubishi Research Institute, Inc.

1.2 A new direction for energy autonomy

Stockpiling and procurement diversification are indispensable initial responses to supply disruptions. Following earlier oil crises, Japan has advanced its energy efficiency, public and private stockpiling, and stronger relationships with oil-producing countries.

In the current crisis, a decision was made on 16 March 2026, to reduce mandatory private-sector stockpiles by 15 days and initially release one month's worth of crude oil from national stockpiles.[4]

The government subsequently implemented further release of national oil stockpiles and extensions of the reduction in private-sector–stockpiling requirements in stages. Meanwhile, it expanded alternative procurement that bypassed the Strait of Hormuz. According to government materials, diversification had progressed to the point where alternative procurement in July and August was expected to reach approximately the same volumes as in normal months of the previous year. The view is that stockpiles bought time to establish alternative procurement.

Stockpiles are finite, however, and procurement from distant alternative sources is affected by shipping times, freight rates, and spot-market volatility. If a crisis persists and its effects extend to naphtha, lubricants, and chemicals, stockpiles and changes in suppliers alone cannot absorb the costs borne by society as a whole. This is not simply an energy-supply issue; it is also a supply-chain issue for materials and products made from petroleum feedstocks. The time secured through stockpiling must therefore be used to transform the supply–demand structure toward energy autonomy: upping demand restraint and domestic supply capacity while improving the ability to switch fuel types, suppliers, transport routes, and demand-side uses.

[4] Ministry of Economy, Trade and Industry, "Reduction of Mandatory Private-Sector Stockpiles and Release of National Oil Stockpiles" (民間備蓄義務量の引き下げ及び国家備蓄石油の放出を行います; in Japanese) https://www.meti.go.jp/press/2025/03/20260316005/20260316005.html (accessed September 7, 2026)



Figure 1-3 Transition from stockpiling and procurement diversification to an autonomous supply–demand structure

Source: Mitsubishi Research Institute, Inc.

Energy and resource security should focus not on maximizing domestic self-sufficiency itself, but on improving the ability to switch supply sources and adjust demand in response to changes in externalities. Japan can strengthen its ability to respond to supply disruptions even without achieving complete domestic self-sufficiency by reducing dependence on particular regions and retaining multiple options for suppliers, supply routes, alternative energy, stockpiles, and demand-side flexibility.

We define *autonomy* as a state in which connections with the outside world are maintained without being constrained by those dependencies, enabling supply and demand to be adjusted and switched independently during a crisis. Whereas *independence* seeks to increase domestic self-sufficiency itself, autonomy strengthens resilience through diverse options and the capacity to switch between them. Japan should pursue such an autonomous energy supply–demand structure (Figure 1-4).

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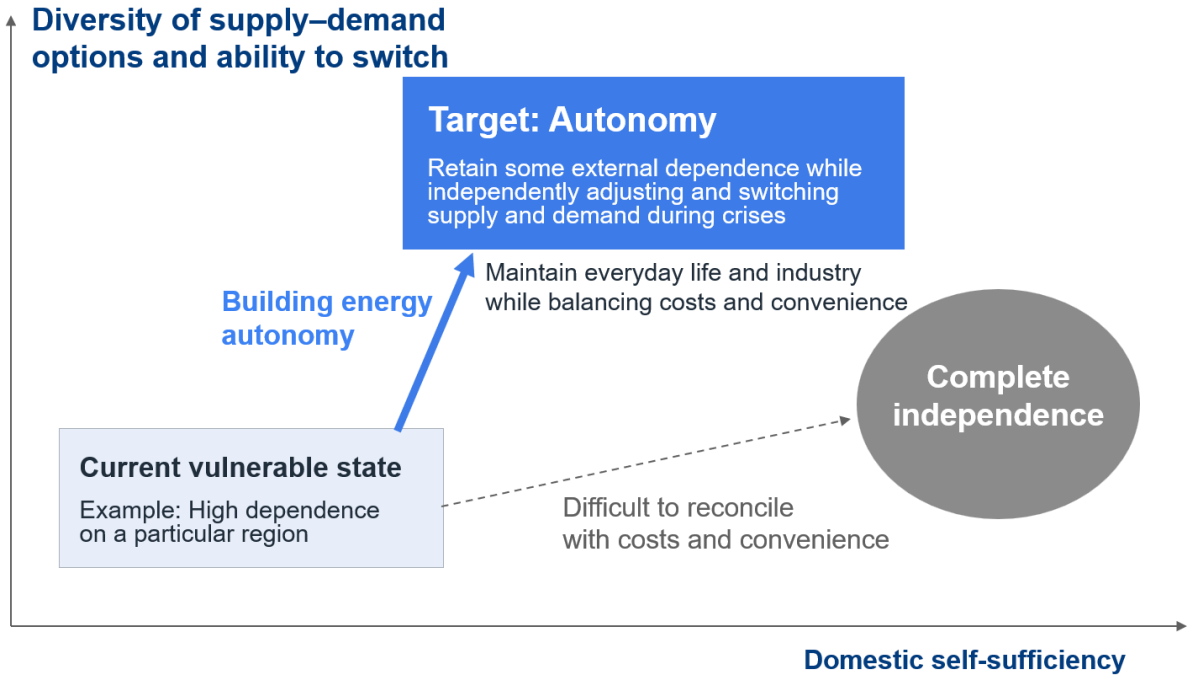


Figure 1-4 Pursuing autonomy rather than independence

Source: Mitsubishi Research Institute, Inc.

Specific measures include reducing demand through equipment replacement and energy efficiency; shifting the timing of demand through demand response (DR), electricity storage, and other means; and switching equipment operation and demand priorities between normalcy and emergency. On the supply side, domestic capacity should be strengthened by using renewables and nuclear energy, utilizing local and unused resources, and reinforcing domestic technologies and supply chains. Risks associated with overseas dependence should also be diversified by spreading procurement sources and upstream interests, establishing multiple routes and modes of transport, and diversifying imported fuels.

To make these measures effective, planners must address short-term changes to operations and medium- to long-term development of infrastructure together. Policy, contracts, and facilities that reconcile efficiency in normalcy with reserve capacity in emergency can create a system that flexibly reconfigures supply, demand, and their priorities to suit the situation. Measures must be implemented and combined across several levels: voluntary adjustment by end users, complementary supply and demand within local areas, national development of policy, stockpiles, and supply chains, and the expansion of options through international and interregional cooperation. We have summarized the three supply–demand transformations toward autonomy and those responsible for implementing them (Figure 1-5).

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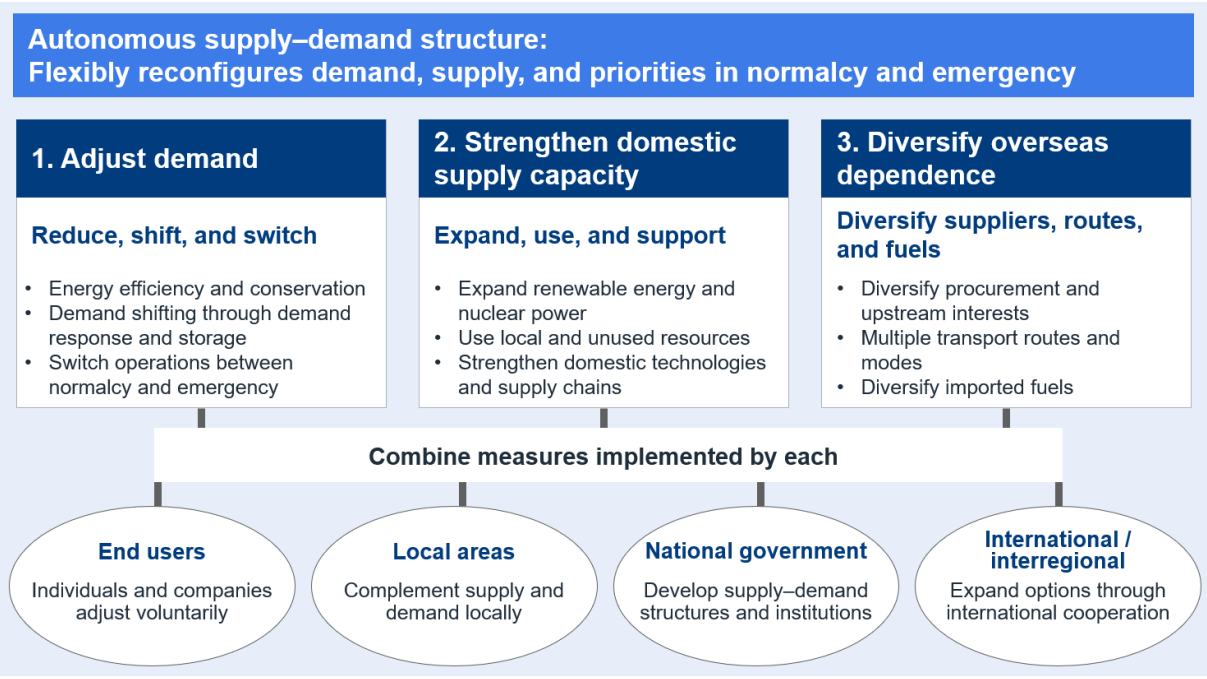


Figure 1-5 Three supply–demand transformations toward autonomy and those responsible for their implementation

Note: Expand domestically sourced energy, including renewables and local resources, while strengthening domestic supply capacity, including nuclear power, which is positioned as quasi-domestic energy
Source: Mitsubishi Research Institute, Inc.

The response to the current crisis should proceed along two pillars: (1) strengthening the resilience of the overall energy supply–demand structure and (2) redesigning oil and petrochemical supply chains that are highly dependent on the Middle East (Figure 1-6). The first pillar strengthens demand-side flexibility, domestic supply capacity, and substitutability between energy sources. The second diversifies suppliers and transport routes for crude oil and naphtha while advancing fuel and feedstock switching, resource circulation, and greater flexibility in refining and logistics infrastructure. Linking these measures with green transformation (GX)investment, equipment replacement, local businesses, stronger human resource foundations, and stronger technological foundations can connect crisis resilience with greater productivity in normalcy, decarbonization, domestic investment, and industrial competitiveness.

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(1) Strengthen resilience of the overall energy supply–demand structure

Vulnerabilities

Optimization for efficiency in normalcy leaves insufficient reserve capacity and flexibility in emergency

Response

- Accelerate autonomy through links with green transformation
- Secure substitution between energy sources and scope for mutual support
- Pursue both green transformation and long-term technological innovation

(2) Redesign oil and petrochemical supply chains

Vulnerabilities

Concentration of crude oil and naphtha procurement in the Middle East; difficulty substituting fuels and feedstocks; rigid refining and logistics infrastructure

Response

- Diversify procurement; switch fuels and feedstocks by application
- Use resource circulation and alternative feedstocks
- Strengthen decentralized resilience through local resources

Figure 1-6 Two pillars connecting crisis response with resilience and industrial competitiveness

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2. Energy autonomy in an era of crisis

In quantifying Japan's energy autonomy, we designed an *energy-autonomy scenario* for fiscal year (FY) 2035 that adds further measures to those implemented under the *business-as-usual (BAU) scenario*, which follows current policies and established plans. We analyzed the effects on the primary–energy-supply mix, fossil-fuel costs, the energy self-sufficiency rate, and greenhouse gas (GHG) emissions. The JPY 1 trillion in avoided costs represents gross fossil-fuel costs avoided during emergencies. It is not a benefit net of the capital, operational, maintenance, and other costs required to realize the energy autonomy scenario.

2.1 A way to avoid JPY 1 trillion in costs during emergencies

2.1.1 Designing an energy autonomy scenario: A holistic approach

Measures aimed at energy autonomy should first be considered separately over long-term and short- to medium-term horizons. In resource-poor Japan, the direction of green transformation overlaps substantially with that of energy autonomy. Over the long-term, it is important to advance initiatives that include the development of innovative technologies for achieving green transformation.

Over the short- to medium-term, green transformation necessitates a faster shift to energy autonomy. Emergencies can occur at any time, whereas it takes time to develop and commercialize the technologies needed to build an energy supply–demand structure with the highest possible resistance to emergencies. The first priority is to further accelerate green-transformation initiatives already under way. In addition, while dependence on fossil fuels remains unavoidable for the time being, maintaining the flexibility to substitute one fossil fuel for another may also be an effective measure.

To quantitatively evaluate the effects of faster and fortified measures, we designed an energy autonomy scenario and analyzed it alongside a BAU scenario (Figure 2-1). For FY2035, we assumed additional deployment and other measures resulting from stronger action over approximately the next ten years in five areas: renewables, nuclear power, coal-fired power, vehicles, and resource circulation. We evaluated the effects of the scenario using the MRI-TIMES model for analyzing energy supply and demand.

Renewables	Expand agrivoltaics and other renewables	+10 GW
Nuclear	Accelerate restarts	+2 GW
Coal-fired power	Retain capacity for use during emergencies	+3 GW
Vehicles	Accelerate electrification	+1.5 million vehicles
Resource circulation	Promote recycled materials and other options	+940,000 tonnes

Figure 2-1 Qualitative and quantitative settings by area in the FY2035 energy autonomy scenario (Relative to BAU scenario)

Note: These deployment figures are cumulative over approximately the next ten years. The corresponding annual additions are +1 GW/year for renewables and +150,000 vehicles/year. The additional renewable capacity is approximately 30% of annual solar photovoltaic deployment in FY2024 (+3-4 GW/year). Additional vehicle deployment is approximately equal to annual EV and PHEV deployment in FY2023 (+140,000 vehicles/year). Resource circulation is assumed to expand at the pace needed to achieve Japan's targets for 2050, increasing the use of recycled and other secondary feedstocks from approximately 1 million tonnes at present to approximately 5 million tonnes

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2.1.2 Applying the energy autonomy scenario: Limiting cost increases during emergencies

We compared the primary-energy–supply mix in FY2035 under the BAU scenario and the energy autonomy scenario during emergencies (Figure 2-2). In the latter, the shares of decarbonized energy sources, such as renewables and nuclear power, rise even in normalcy. Additional use of coal-fired power during emergencies creates a structure that can reduce dependence on liquefied natural gas (LNG) and oil.

We also examined the cost relationship between the both scenarios (Figure 2-3). While energy autonomy can reduce fossil-fuel costs, costs across the energy system as a whole may rise to some extent in normalcy. In emergency, however, limiting imports of expensive fossil fuels can substantially restrain cost increases relative to the BAU scenario. Japan must therefore consider benefits in emergency as well as in normalcy. From the perspective of sustaining societal infrastructure and activity, it is also important to narrow the gap between costs in normalcy and emergency, thereby mitigating disruption caused by external shock.

We also focused specifically on fossil-fuel costs, looking at the difference between and the breakdown of both scenarios (Figure 2-4). By measure, the reductions are approximately JPY 300 billion each for renewables and nuclear power, approximately JPY 200 billion for coal-fired power, and approximately JPY 100 billion each for vehicles and resource circulation. In total, the energy autonomy scenario results in approximately JPY 1 trillion in avoided costs during emergencies.

As these results show, no single measure generates reductions on the scale of JPY 1 trillion. Mobilizing a broad range of technologies produces substantial aggregate in avoided costs.

Energy autonomy has positive effects not only in limiting fossil-fuel costs during emergencies, but also on the energy self-sufficiency rate and GHG emissions (Figure 2-5). The energy self-sufficiency rate improves by 1.3%p in both normalcy and emergency, while GHG emissions decline by 1.6%p in normalcy. Although emissions increase in emergency relative to normalcy because of greater use of coal-fired power, they remain 0.8%p below the BAU scenario. Some emissions reduction is therefore maintained even in emergency.

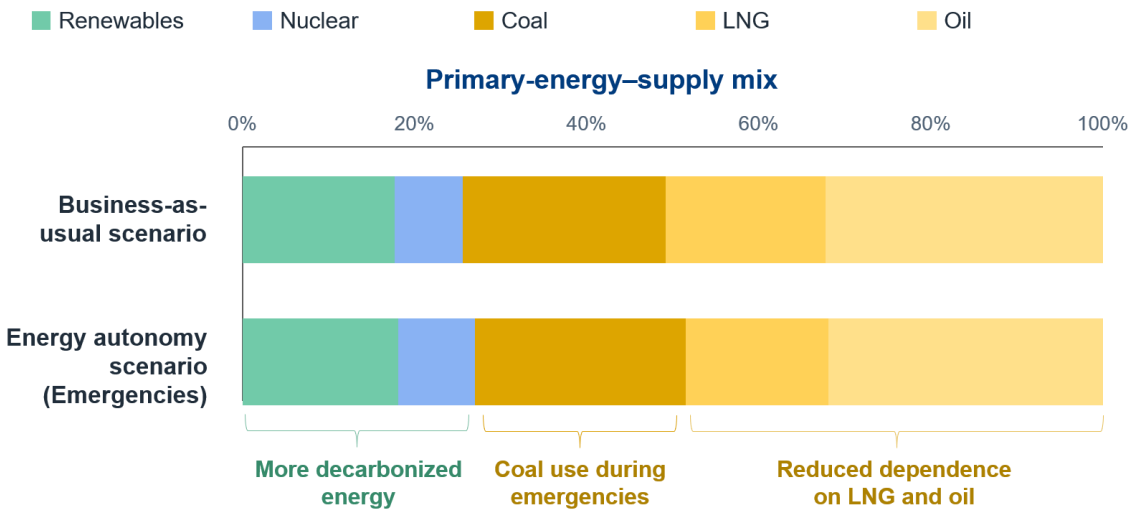


Figure 2-2 Primary-energy–supply mix under the BAU scenario and the energy autonomy scenario during emergencies (FY2035)

Note: The transition from the BAU scenario to the energy autonomy scenario raises the shares of renewables and nuclear power even in normalcy; coal-fired power is used additionally in emergency
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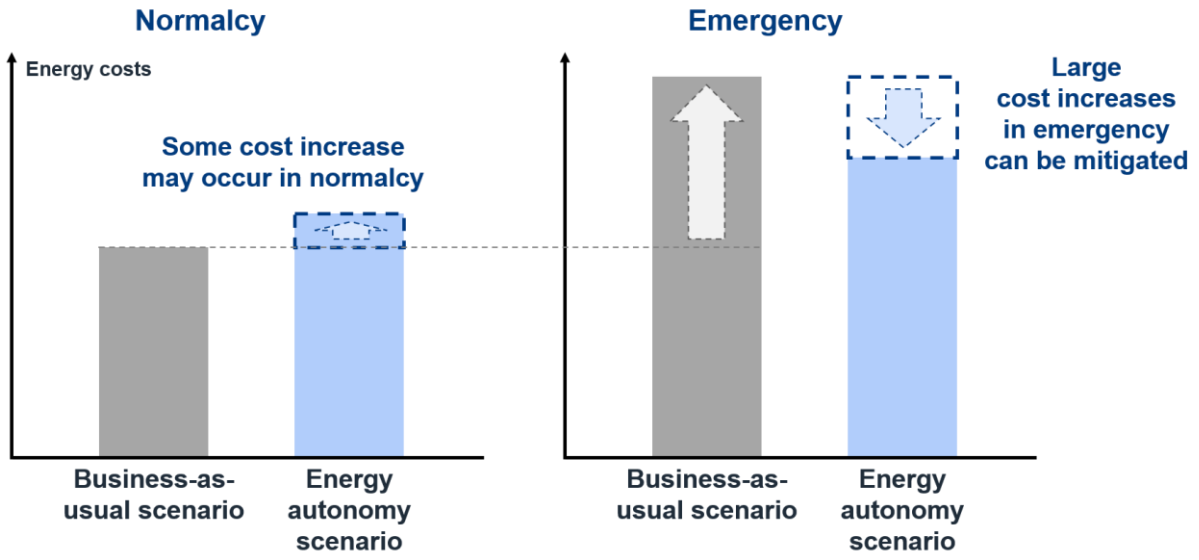


Figure 2-3 Energy costs under the BAU and energy autonomy scenarios in normalcy and emergency (Conceptual diagram)

Source: Mitsubishi Research Institute, Inc.

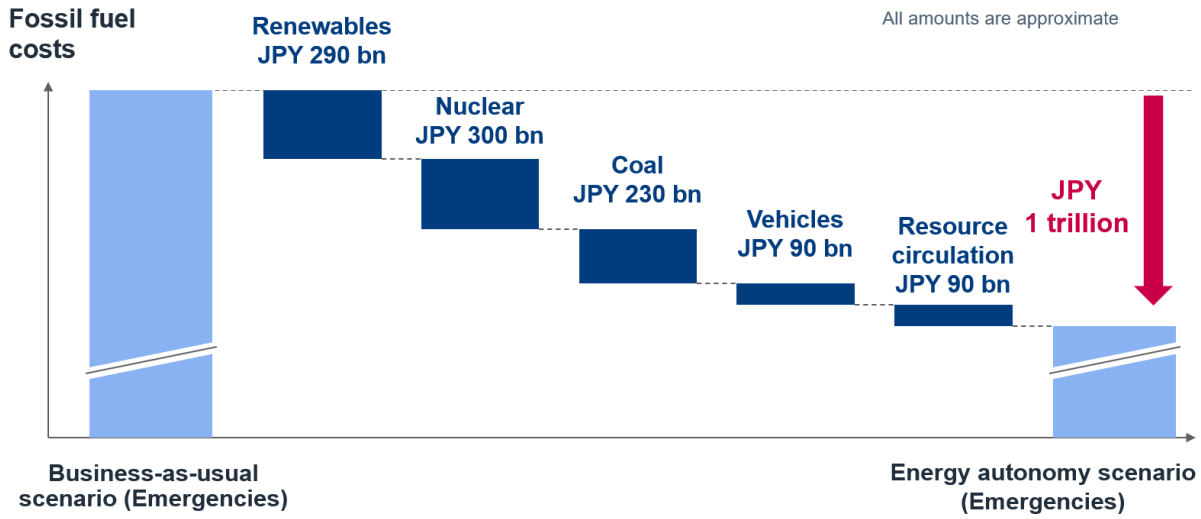


Figure 2-4 Breakdown of fossil-fuel costs avoided during emergencies under the FY2035 energy autonomy scenario (Relative to BAU scenario)

Main estimation assumptions

- Emergency fossil-fuel prices are assumed to persist for one year, based on 2022 and the current situation: oil at 1.5 times, LNG at 2.4 times, and coal at 2.1 times their levels in normalcy
- All of the additional 10 GW of renewable capacity is assumed to be solar photovoltaics
- The additional 2 GW of nuclear capacity is added mechanically relative to BAU scenario, without identifying specific plants
- An additional 3 GW of coal-fired capacity relative to BAU scenario is assumed to be available in emergency
- For vehicles, fossil-fuel savings are calculated for the electric-driving portion of BEVs and PHEVs
- For resource circulation, naphtha substitution is evaluated through mechanical recycling, chemical recycling, and biomass-derived plastics

Note: The figures represent reductions in fossil-fuel costs, not net benefits after deducting the capital, operational, and maintenance, and other costs required for each measure

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	Energy self-sufficiency rate	GHG emissions
Normalcy	+1.3%p	-1.6%p
Emergency	+1.3%p	-0.8%p

Figure 2-5 Changes in the rate of energy self-sufficiency and GHG emissions under the energy autonomy scenario (Relative to BAU Scenario)

Note: Coal-fired power is used more extensively in emergency than in normalcy. Because this substitutes for one fossil fuel for another, the energy self-sufficiency rate is almost unchanged between normalcy and emergency
Source: Mitsubishi Research Institute, Inc.

2.2 Specifics by sector

Achieving the energy autonomy scenario would have substantial effects, but each component faces challenges that must be overcome. We considered the direction in which efforts should proceed if Japan is to overcome the high hurdles facing each sector on the road to energy autonomy.

2.2.1 Renewable energy: Design for new leadership and value

Renewable energy is expected to deliver multiple benefits, including not only decarbonization but also energy security and reduced exposure to fuel-price volatility. Our analysis shows that expanded renewable deployment avoids approximately JPY 290 billion in fuel costs during emergencies. While the benefits of additional deployment are substantial, there are also many challenges: harmonious coexistence with local communities, including landscape concerns; global inflation; and cost increases arising from higher material prices and interest rates. Precisely under these circumstances, Japan must assess deployment benefits from the perspective of both normalcy and emergency and to consider the appropriate degree of policy support.

Since Japan launched its feed-in tariff (FIT) program in 2012, renewables have seen substantial expansion through policy support for the supply side. Going forward, deployment too must expand as renewables are increasingly integrated into markets. Here, three points will be particularly important: (1) demand-led deployment, (2) communicating diverse forms of value, and (3) the design of policy tailored to the characteristics of each generation technology.

(1) Demand-led deployment

Electricity users will need to manage procurement more proactively in response to rising geopolitical risks, changes in the macroeconomic environment, and decarbonization trends. Renewables tend to have a high proportion of fixed costs and, once operational, are relatively less affected by fossil-fuel prices and inflation. Medium- to long-term corporate–power-purchase agreements (corporate PPAs)[5] can therefore serve as a hedge against fluctuations in the price of electricity. Such contracts also improve project predictability and support investment in new renewable capacity, including by facilitating financing.[6] Moreover, developments such as the

[5] A long-term power-purchase agreement concluded between an electricity user and a power generator or retailer

[6] Microsoft has concluded a 20-year power-purchase agreement for solar power with Shizen Energy

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proposed revision of the GHG Protocol[7] may place greater emphasis on higher-quality renewable energy in decarbonization efforts.

Renewables will increasingly need to be chosen by electricity users on these grounds. At the same time, users must become actors that support new deployment through commitments to renewable procurement. Reflecting recognition of this role, the Japanese government's program designating strategic regions for green transformation provides certain subsidies to electricity users that meet the conditions to be recognized as entities contributing to their region with decarbonized power sources. It is also important to broaden participation beyond large companies through measures such as joint renewable procurement involving small- and medium-sized enterprises.[8]

(2) Communicating diverse forms of value

In addition to environmental value, renewables provide other forms of value, including the electricity-price–hedging function and contributions to local communities. Co-locating batteries enables variable renewables, such as solar and wind power, to create value through flexibility and other services. Communicating the diverse forms of value of electricity beyond its environmental attributes is important for improving the profitability of generation projects and supporting further deployment.

There is also scope to contribute to resolving challenges outside the energy sector; creating synergies through broader cross-sector collaboration can expand the opportunities for stakeholders to share the resulting benefits.

For example, farmland is expected to offer substantial potential for solar power. At the same time, maintaining and managing farmland is becoming a major challenge as population declines and the number of farmers falls. If agrivoltaics can be structured to improve the sustainability of farming, the resulting value can be shared between agrivoltaic generation and agriculture (Chapter 4).

(3) Policy design tailored to generation characteristics

Cost structures, development lead times, and levels of maturity vary significantly across renewable sources and technologies. While pursuing market integration and competitive generation overall, it is also important to design detailed support measures and policy suited to the specific circumstances of each technology (Figure 2-6).

Solar power, for example, faces scarcity in suitable sites for ground-mounted installations. Here, rooftop systems are receiving focused deployment support as they use existing space and offer advantages in coexistence with local communities.

Offshore wind is on track for a scaleup in its deployment, but costs are being driven up by global inflation and rising material prices. Planners must therefore consider project deliverability rather than price competition alone. Next-generation geothermal technologies, meanwhile, remain at a low level of maturity but could better tap into Japan's geothermal potential. Rather than short-term support for electricity sales, efforts toward technological development should begin now from a medium- to long-term perspective.

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[7] Hourly matching, deliverable regions, and related issues are at the public consultation stage.
GHG Protocol, "Scope 2 Public Consultation Summary of Feedback: Executive Summary" https://ghgprotocol.org/sites/default/files/2026-07/S2-ExecutiveSummary-PublicConsultation%20ummaryofFeedback-2026.07.29.pdf (accessed 7 September 2026)

[8] Under its "Development of New Renewable Energy Deployment Models Contributing to Value-Chain Decarbonization" (バリューチェーンの脱炭素化に資する新たな再エネ導入モデル構築事業; in Japanese) program, the Ministry of the Environment promotes PPA models involving collaboration among companies along value chains

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	Direction	Current developments and future possibilities
Demand-led deployment	• End users proactively manage electricity procurement • Long-term contracts support new capacity	• Demand-side support for green transformation strategic regions • Joint procurement along value chains
Communication of diverse forms of value	• Communicate value beyond environmental attributes • Create synergies across sectors	• Capacity and flexibility from co-located storage • Address agricultural challenges through agrivoltaics
Technology-specific policy design	• Assess differences in cost structures and development lead times • Design policy around bottlenecks	• Development risks in offshore wind • R&D for next-generation geothermal

Figure 2-6 Direction that further deployment of renewable energy should take

Source: Mitsubishi Research Institute, Inc.

2.2.2 Nuclear power: Rethinking from cost-benefit analysis

Converted to a single nuclear power unit of approximately 1 GW, we estimate annual fuel-cost reductions of approximately JPY 150 billion during emergencies by replacing LNG-fired generation.[9] This scale provides a starting point for considering the value of restarting nuclear reactors.

We examined whether the benefits justify the costs. Restarts require statutory procedures, including review by the Nuclear Regulation Authority for conformity with new regulatory requirements: permission to amend reactor installations, approval of design and construction plans, and approval of operational safety programs. The necessary construction work and inspections must also be completed. Separately, national and local governments must also develop concrete regional plans for disaster prevention and evacuation.

The largest restart-related cost is expenditure on additional safety measures. Materials compiled by the government's Power Generation Cost Verification Working Group from nuclear operators' estimates put this expenditure at an average of approximately JPY 266.2 billion per reactor.[10] For comparison with annual benefits, allocating this expenditure evenly over an illustrative ten-year period gives approximately JPY 26.6 billion per year.[11] Adding nuclear emergency preparedness and evacuation measures, such as evacuation roads and indoor shelter facilities, would bring the total annual amount to the order of tens of billions of yen. Even so, approximately JPY 150 billion in annual fuel cost savings from replacing LNG-fired generation over one year of emergency conditions substantially exceeds this annualized restart-related burden. However, because emergencies do not occur every year, this does not establish that restart costs can be fully recovered. The conclusion may change depending on the assumed frequency of emergencies.

Considering normalcy changes the equation. Nuclear power emits no CO_2 during generation and

[9] The preceding estimate for 2 GW is simply converted to a per-1-GW basis, taking into account the typical capacity of light-water reactors, which predominate among commercial reactors in Japan. The actual electrical output differs by reactor unit

[10] The average for the 27 reactors that had applied for review of compliance with the new regulatory requirements as of June 2024

[11] The ten-year period is used solely as a convenient assumption for annualizing the additional safety measure costs. It is not an accounting depreciation period

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provides supply capacity that is independent from fossil-fuel costs and weather. It thus has potential to reduce outflows of national wealth through lower fuel procurement, to improve the generation mix's resistance to fuel-price volatility, reduce CO_2 emissions, and to secure reserve capacity when supply and demand are tight. These benefits contribute to the stability and decarbonization of Japan's electricity system on a day-to-day basis, without waiting for the extreme conditions of an emergency. The value of restarting reactors is therefore not confined to temporary benefits during emergencies; it extends to every year of operation.

The same perspective applies to costs. Although restart costs have so far been converted into annual amounts for comparison with benefits, nuclear power costs are not uniform. Some arise newly when reactors restart while others continue regardless of whether they operate. For example, nuclear operators as a whole shoulder about JPY 300 billion yearly in back-end costs, including spent-fuel reprocessing, waste disposal, and contributions and reserves for compensation.[12] Other prominent costs include those for regional development and coexistence with local communities, including industrial development, employment, human resource development, infrastructure for residents, and measures addressing reputational damage. Some operators make contributions in the range of several billion to more than ten billion yen annually, depending on factors such as scale of nuclear generation. Certain costs thus continue even while nuclear plants are shut down, whereas benefits such as generation revenue, fuel-cost savings, and contributions to decarbonization cannot be realized until after restart.

Clearly, conformity reviews and dialogue with local communities cannot be rushed solely for economic reasons. Maintenance and safety work during shutdown also play a role in preserving equipment integrity, technical expertise, and employment. Nevertheless, the longer a shutdown continues without restart, the longer essential costs continue without the benefits of generation. This point needs to be acknowledged directly. We have put together the costs and benefits during shutdown and after restart (Figure 2-7).

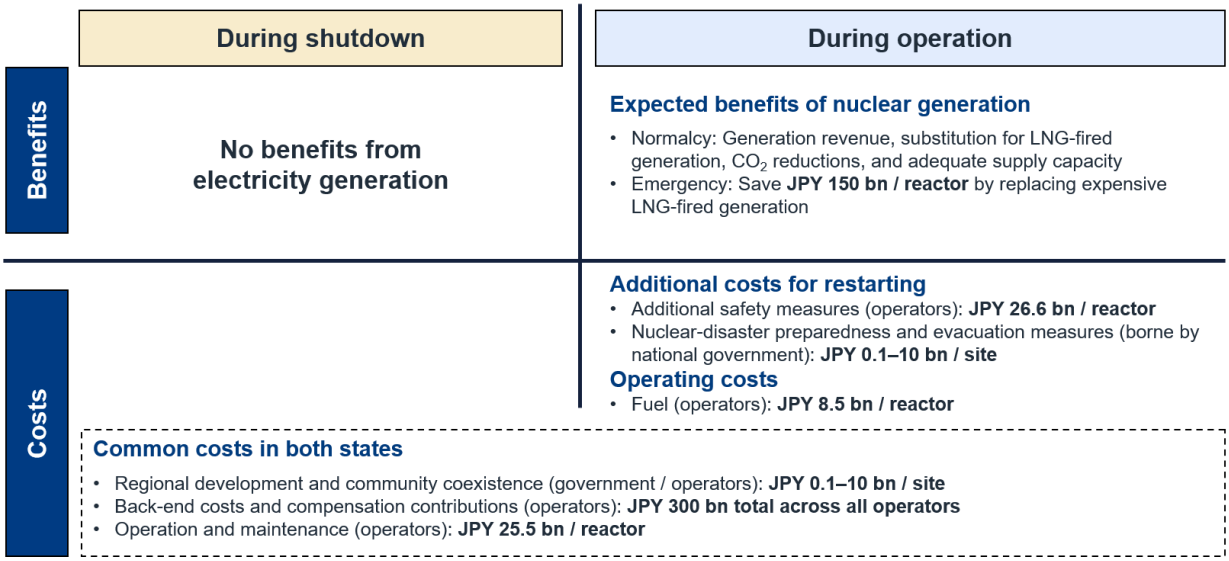


Figure 2-7 Annual benefits and costs of nuclear power during shutdown and operation (Principal cost bearers in parentheses)

[12] An approximate total of decommissioning contributions of JPY 42.5 billion (FY2026), high-level radioactive waste final disposal contributions of JPY 72.5 billion (FY2024), and general compensation contributions of JPY 194.7 billion (FY2024). These annual figures are added directly; note that the fiscal years are not aligned

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Note:
- All monetary amounts are approximate annual figures
- The benefit of replacing LNG-fired generation is a proportional conversion of our estimate for restarting 2 GW during emergencies (approximately JPY 300 billion/year) to one nuclear unit of approximately 1 GW
- Additional safety expenditure is annualized by allocating the average estimate submitted by power companies to the government's Power Generation Cost Verification Working Group (approximately JPY 266.2 billion/reactor) evenly over an illustrative ten-year period
- Back-end costs and compensation contributions are approximated by simply adding published amounts for decommissioning contributions, contributions for the final disposal of high-level radioactive waste, and general contributions for nuclear damage compensation
- Operation and maintenance costs and fuel costs are per model plant in the Power Generation Cost Verification Working Group's estimates. Operation and maintenance costs comprise personnel, repairs, miscellaneous expenses, and allocated operating expenses; most continue during shutdown
- Costs for regional development and community coexistence as well as nuclear-disaster preparedness and evacuation measures vary substantially by the characteristics of each site and how related policies are designed. The figures therefore indicate orders of magnitude. Regional development and community coexistence costs include grants for measures in the regions that host power plants and operators' voluntary contributions at actual cost

Source: Mitsubishi Research Institute, Inc.

The relationship between costs and those who bear them also deserves attention. Operators bear additional safety and back-end costs, while nuclear-disaster preparedness and evacuation measures fall primarily within the national government's responsibilities. Community-coexistence costs combine public expenditure with operators' contributions. A substantial part of the measures needed to achieve the benefits of restarting reactors therefore lies with the national government. With safety as the highest priority, there may be scope for more proactive government involvement in accelerating restarts, including:

- Improving predictability regarding the time required for conformity reviews
- Specifying the required expenditure, timetable, and funding sources for nuclear-disaster preparedness and evacuation measures that the national government should undertake
- Providing a path for recovering the costs of long-term obligations, including back-end costs and provisions for compensation

Restarts, however, are a response based on existing reactors and do not by themselves ensure the medium- to long-term sustainability of nuclear power. With operating-life limits applying to existing reactors, the government has indicated a policy of moving forward, subject to certain conditions, with replacement by next-generation advanced reactors at sites where decommissioning has been decided. Presenting an integrated approach to securing near-term supply capacity through restarts and to replacement and new construction for the 2040s and beyond is itself one form of involvement required of the government.

2.2.3 Coal-fired power: Crisis brings forth benefits

Japan currently has a capacity of approximately 50 GW for coal-fired generation. Over the next ten years, 10–20 GW of capacity is expected to reach 40 years since commissioning, and service suspensions and facility retirement are inevitable.[13] With costs avoided during emergencies in mind, the energy autonomy scenario assumes that an additional 3 GW of existing coal-fired capacity is retained. If the cost of retaining this capacity is assumed to match the indicative price in the third solicitation under the reserve power source system (JPY 14,860/kW),[14] the cost of retaining 3 GW of

[13] A mechanical aggregation of the approved capacities of coal-fired plants rated at 100 MW or more listed in the Japan Electric Power Exchange (JEPX) "Power Generation Information Disclosure System (HJKS)" (発電情報公開システム（HJKS）; in Japanese)
https://hjks.jepx.or.jp/hjks/top (accessed 7 September 2026)

[14] Agency for Natural Resources and Energy, "Guidelines for the Reserve Power Source System (August 2026)" (予備電源制度ガイドライン（令和 8 年 8 月）; in Japanese)
https://www.enecho.meti.go.jp/category/electricity_and_gas/electric/summary/regulations/pdf/guideline_yobidengen.pdf (accessed 7 September 2026)
Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO), "Reserve Power Source Solicitation Guidelines (Third Round)" (予備電源募集要綱（第 3 回募集分）; in Japanese)
https://www.occto.or.jp/assets/yobidengen/files/yobidengen_boshuyou_260819.xlsx/87b558dd6ee1ff7e91006fc257a61741.pdf (accessed 7 September 2026)
The benchmark of JPY 14,860/kW is the maximum bid price for the third solicitation. Actual retention costs for individual coal-fired plants can differ according to plant-specific conditions

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existing coal-fired capacity is approximately JPY 45 billion per year. The estimated avoided costs during emergencies are JPY 230 billion. On the assumption that an emergency occurs once every five to six years, the benefits of avoided costs during emergencies would exceed the cost of retaining suspended coal-fired capacity. These estimates rest on specific assumptions, and the results may change depending on factors such as the treatment of coal-fired power in normalcy. Nonetheless, cost-effectiveness should be assessed objectively, including the avoided costs during emergencies. We have put together an outlook on coal-fired capacity, including these interrelated estimates (Figure 2-8).

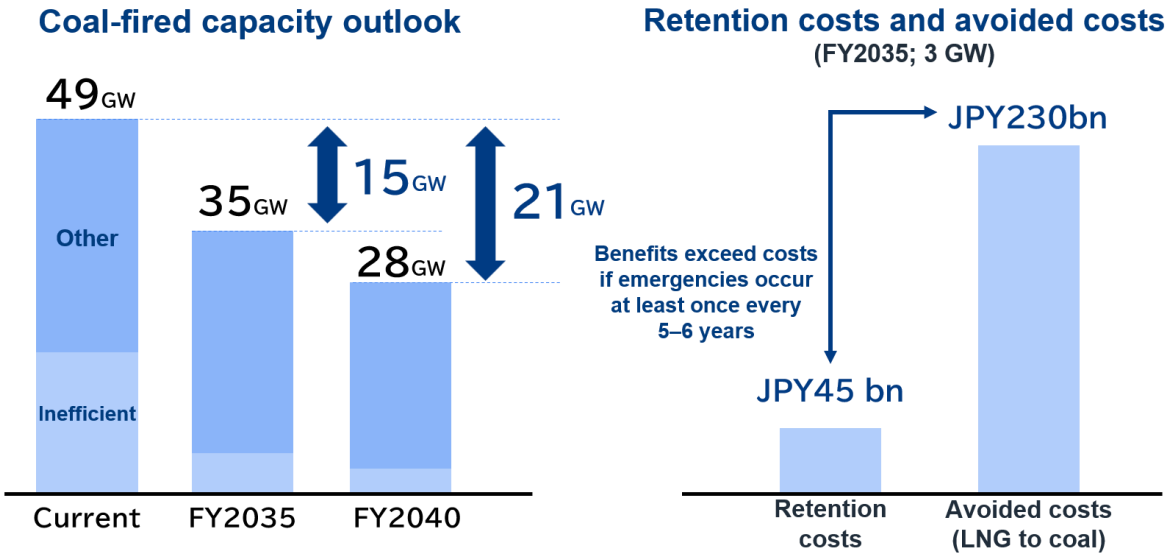


Figure 2-8 Coal-fired capacity outlook, retention costs, and fossil-fuel costs avoided during emergencies[15]

Source: Mitsubishi Research Institute, Inc.

Diversifying electricity supply is important for achieving energy autonomy. However, new generation takes time to develop, and it is essential to make full use of currently available sources over the short- to medium-term. While the need for decarbonization must be kept in mind, coal-fired power, with its diverse fuel-procurement sources and stockpiling characteristics, can play a role in securing supply capacity and diversifying fuel-procurement risks. From the perspective of emergency preparedness, it is therefore necessary to consider how existing coal-fired capacity should be retained and used.

This concern is not limited to emergency preparedness. Alongside the aging of thermal generation, electricity demand is expected to increase, making adequate supply capacity in normalcy an important issue in its own right. Maximizing the use of existing generation is consequently becoming more important both for emergency preparedness and for stable supply in normalcy. Recent policy discussions have considered how to secure future supply capacity while making the fullest use of existing sources. Going forward, decisions on retaining, suspending, or retiring existing generation should not be made solely plant by plant. They should also consider its bridging role until new capacity becomes available, together with the direction for retaining and using existing coal-fired power and the policy needed to enable it.

For thermal generation to remain a major source

[15] The FY2035 and FY2040 coal-fired capacity estimates include only facilities within 40 years of the start of operation

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of supply over the long term, however, decarbonization is indispensable, including technological options such as carbon capture, utilization, and storage (CCUS), hydrogen co-firing, and ammonia co-firing. Establishing technologies and installing facilities for decarbonized thermal generation takes time, making a rapid transition difficult. Existing sources therefore also have an important bridging role during the transition. The role that existing coal-fired power can play should be considered alongside steady progress toward future decarbonization.

2.2.4 Oil: Vehicles and resource circulation

Combining electrification and sustainable fuels according to use can reduce transport-sector oil demand and ease the costs associated with crude oil procurement, refining, and delivery during emergencies. We quantified the effect of electrifying passenger cars and similar vehicles, estimating that deploying an additional 1 million battery electric vehicles (BEVs) and 500,000 plug-in hybrid electric vehicles (PHEVs) relative to the BAU scenario by FY2035 could reduce fossil-fuel costs during emergencies by approximately JPY 90 billion. This corresponds to average additional annual deployment of approximately 100,000 BEVs and 50,000 PHEVs.

BEVs and sustainable fuels are not mutually exclusive alternatives; they play complementary roles depending on vehicle use and replacement conditions.[16] Switching to energy-efficient BEVs should be prioritized for private cars, company cars, and local delivery vehicles where regular charging is readily available and daily driving distances and routes are predictable. On the other hand, commercial and heavy-duty vehicles serving long-distance trunk routes are constrained by charging time and payload, and there are segments where existing internal combustion vehicles will remain for a long time. Here, sustainable fuels such as biofuels and synthetic fuels can complement electrification by reducing oil demand that is difficult to electrify. PHEVs offer a transitional option, but their oil-saving effects depend on routine charging and a high share of electric driving.

Realizing this division of roles requires integrated development of the automotive sector and energy-supply infrastructure. The government is aiming for 100% of new passenger car sales in 2035 to be electrified vehicles[17]. It is also aiming for the installation of 300,000 charging points by 2030, including 30,000 public fast-charging points.[18] There were about 68,000 charging points at the end of FY2024.[19] Japan will need to advance charging at apartment buildings, workplaces, logistics hubs, and expressways, achieve higher charging power, reinforce the grid, and deploy smart charging technology. For sustainable fuels, it is likewise important to build supply chains covering feedstock procurement, domestic production, imports, storage, and supply, enabling priority provision to uses that are difficult to electrify.

During emergencies, greater BEV deployment allows the energy sources for passenger cars and local delivery to extend beyond gasoline and diesel

[16] Mitsubishi Research Institute, Inc. "The Role of Sustainable Fuels in Achieving Net Zero" (ネットゼロに向けた持続可能な燃料の役割とは; in Japanese) https://www.mri.co.jp/news/press/20240927.html

[17] Electrified vehicles: Electric vehicles (EVs), fuel cell vehicles (FCVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs)

[18] Ministry of Economy, Trade and Industry, "Guidelines for Promoting Charging Infrastructure Development" (充電インフラ整備促進に向けた指針; in Japanese) https://www.meti.go.jp/press/2023/10/20231018003/20231018003.html (accessed 7 September 2026).

[19] Approximately 68,000 charging points at the end of FY2024: about 12,000 fast and 56,000 standard charging points.
Ministry of Economy, Trade and Industry, "Efforts to Promote Charging Infrastructure Development" (充電インフラ整備促進に関する取組; in Japanese) https://www.meti.go.jp/policy/mono_info_service/mono/automobile/setseibizyoukyou.pdf (accessed 7 September 2026)

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to electricity, including renewable and nuclear generation. Sustainable fuels can meanwhile serve long-distance transport, heavy-duty vehicles, and existing vehicles that are difficult to electrify. Establishing a structure in normalcy that can use electricity and fuels according to the application makes it easier to maintain transport functions when supplies of a particular fuel are constrained.

In petrochemicals, reducing consumption and extending product life can be combined with circulating domestically collected waste plastics and switching to alternative feedstocks, such as those derived from biomass. This can reduce dependence on fossil-derived naphtha and ease the costs of feedstock procurement and transport during emergencies. We estimated reductions in fossil-resource–procurement costs through naphtha substitution based on our vision for Japan's circular economy in 2050 (Figure 2-9), using figures for FY2035 that fit that scenario. Specifically, we propose increasing the use of recycled and other secondary feedstocks from approximately 1 million tonnes at present to approximately 5 million tonnes in 2050.

Options for switching carbon feedstocks need to be combined according to resource circulation priorities and end uses. First, reducing consumption and extending product life should suppress demand for new feedstocks. Materials that are easy to sort and recycle should then be circulated as materials through mechanical recycling. Those that are difficult to recycle as materials should be converted back into chemical feedstocks through chemical recycling, with remaining demand for new carbon supplemented by sustainable biomass-derived and other feedstocks.

This portfolio of carbon feedstocks combines domestically circulated carbon, renewable carbon, and the minimum necessary fossil carbon, and integrated development will be essential if we are to achieve it. Integration must span the full range of processes, from product design through collection, sorting, recycling, and feedstock use. Specific measures include the use of single materials, design for easy disassembly, expanded collection, advanced sorting, and ensuring greater consistency when it comes to the quality of recycled materials. We must also gradually shift refineries and petrochemical facilities into hubs capable of accepting diverse carbon feedstocks, including materials derived from biomass and waste plastic.

During emergencies, maximizing the use of domestically circulated carbon and supplementing shortages with feedstocks derived from biomass and other sources can mitigate the effects of disruptions to the supply of naphtha imports and price surges. Recycled feedstocks, however, face constraints on collection volumes and quality, while biomass-derived feedstocks face constraints on supply volumes, sustainability, and import dependence. It is therefore important to diversify carbon feedstocks by combining domestically circulated carbon, renewable carbon, and the minimum necessary amount of fossil carbon, without relying on a single technology or feedstock (Chapter 3).

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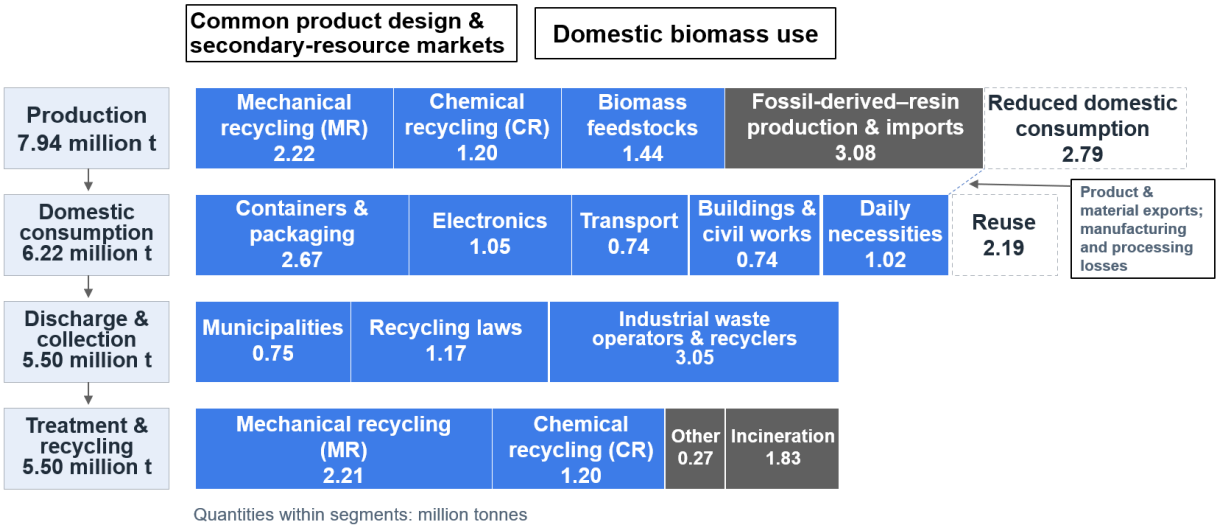


Figure 2-9 Plastic resource circulation flows: The desirable state for 2050

Source: Mitsubishi Research Institute, Inc. "Opening the Way to Japan's Circular Economy through Technology and Collaboration: A Future Vision for Plastic and Battery Resource Circulation" (テクノロジーと協調で拓くわが国の循環経済-プラスチックと蓄電池の資源循環未来像-; in Japanese)
https://www.mri.co.jp/knowledge/insight/policy/20230705.html

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3. Residual oil demand and supply chain redesign

Oil demand is declining over the long-term, but demand remains difficult to substitute in the short- to medium-term for aviation, shipping, freight transport, petrochemical feedstocks, and disaster response. Instead of trying to eliminate oil uniformly, Japan should work to prioritize reductions in demand that can be substituted while transforming the supply network so that the required petroleum products reliably reach the places where demand remains.

During the 2026 Strait of Hormuz Crisis, even when Japan could secure the total volume of oil it needed, it still had to address uneven supply and bottlenecks by product and distribution stage, including naphtha, lubricants, and naphtha-derived paints and thinners. This demonstrates that securing the aggregate volume of crude oil does not necessarily ensure reliable delivery of the petroleum products required for individual uses.

As demand contracts, supply-side constraints must be aligned with residual demand. These include refineries' co-production characteristics and product mix, stockpiles, import terminals, and domestic logistics. Rather than treating demand and supply separately, we have considered end uses, product types, facilities, stockpiles, and logistics together. We have identified ways for Japan to redesign its system so that it can reliably supply essential petroleum products even as demand declines.

3.1 The oil supply–demand structure

Japan's oil demand has declined since its peak in the late 1990s. The industrial and residential sectors have made progress in switching from heavy fuel oil to electricity and gas, energy conservation, and equipment efficiency improvements (Figure 3-1). By FY2024, sales of petroleum fuels fell had fallen by 40% from their historical peak.

In contrast, oil consumption in passenger and freight transport has increased relative to FY1973, and gasoline, diesel, and jet fuel have taken larger shares by product. The decline in naphtha demand reflects not only domestic feedstock switching and lower demand, but also a shift toward overseas production and imports of midstream synthetic resins, such as polyethylene and polypropylene, and downstream products, including packaging films and containers, automotive parts, and electrical and electronic components. Oil demand is not contracting uniformly; it is becoming concentrated in transport fuels and chemical feedstocks.

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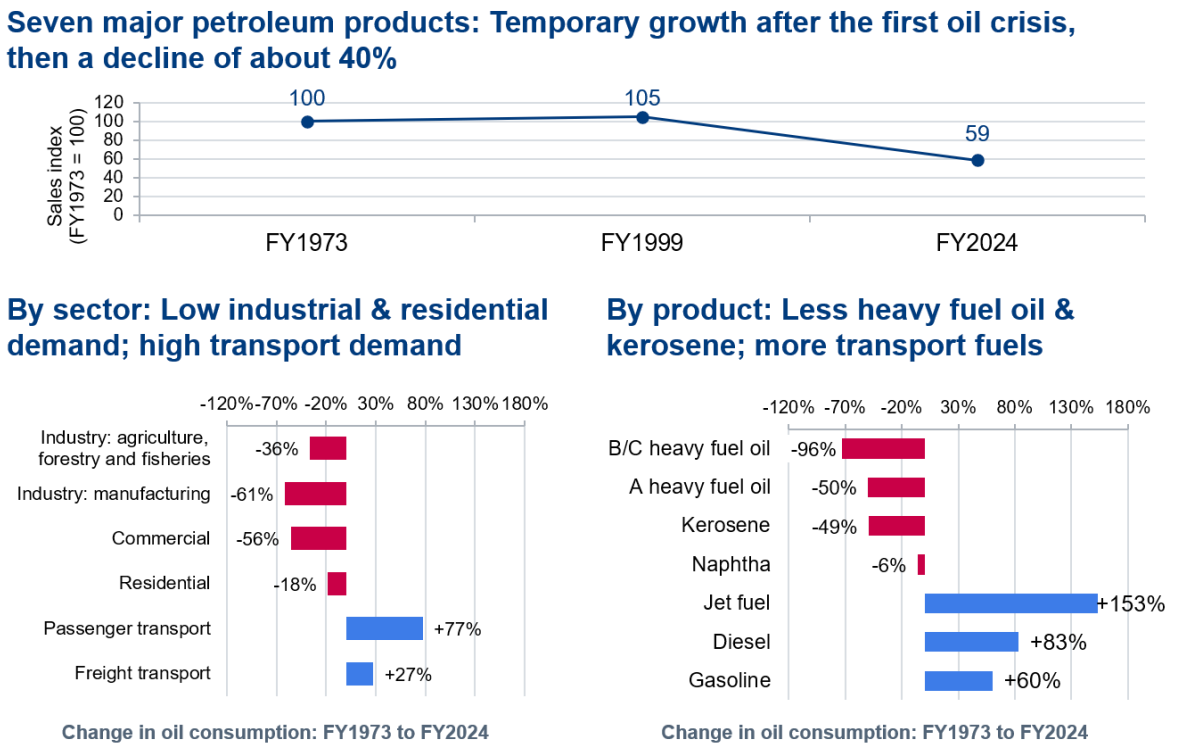


Figure 3-1 Structure of Japan's oil demand

Note: Sectoral figures are based on Japan's Comprehensive Energy Statistics. Long-term comparisons are indicative because statistical methods have changed

Note: Declining naphtha sales may result not only from domestic feedstock switching and lower demand, but also from substitution by overseas production and imports of midstream and downstream chemical products. Lower domestic demand does not necessarily indicate progress in the transition

Source: Mitsubishi Research Institute, Inc. from the Agency for Natural Resources and Energy's Comprehensive Energy Statistics (総合エネルギー統計) and Petroleum Statistics (石油統計); both in Japanese

Transition priorities must be assessed along two dimensions (Figure 3-2): demand volume and oil dependence. Passenger mobility, freight transport, and manufacturing feedstocks have both large oil demand and high oil dependence, making them areas where oil consumption reductions can have substantial effects. Structural demand reduction in these applications therefore requires a combination of more efficient use, electrification, and switching to alternative fuels and feedstocks. Aviation and agriculture, forestry, fisheries, mining, and construction have relatively small oil demand but extremely high oil dependence. For these uses, securing alternatives suited to their characteristics is more important than simply reducing demand. In areas where oil dependence has already declined, including residential and commercial uses, feedstocks in manufacturing, and the energy-transformation sector, the basic approach is to continue switching to other energy sources.

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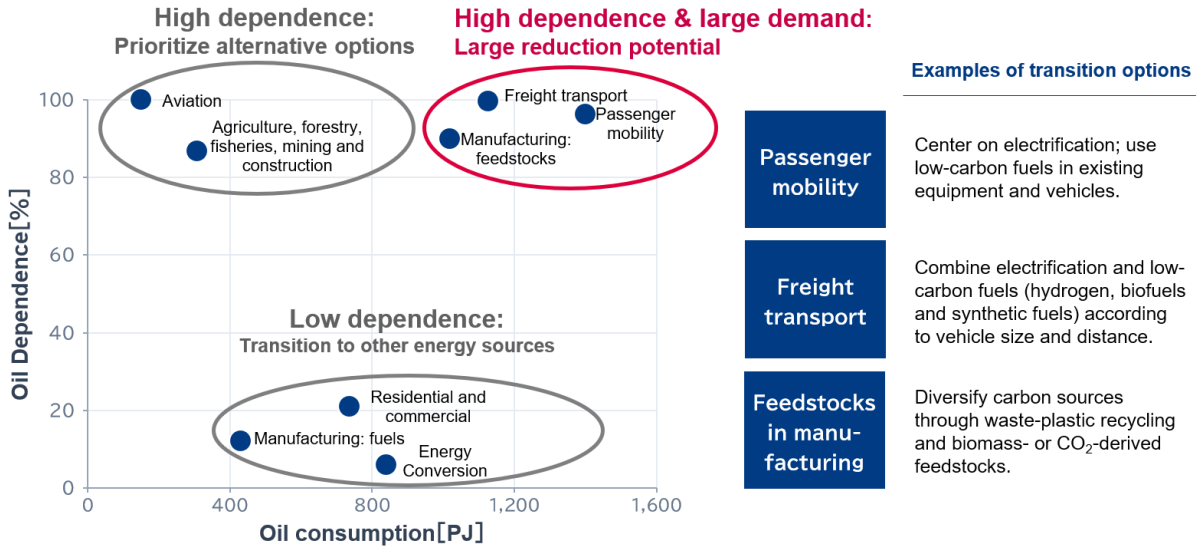


Figure 3-2 Relationship between oil consumption and oil dependence

Note: Oil dependence in energy conversion is an indicative measure calculated as oil's share of the energy input to conversion processes
Source: Mitsubishi Research Institute, Inc. from the Agency for Natural Resources and Energy's Comprehensive Energy Statistics (FY2024) (総合エネルギー統計（2024 年度）; in Japanese)

On the supply side, petroleum products are co-products produced simultaneously from crude oil, making it difficult to adjust supply volumes completely independently by product. If refinery crude throughput is reduced in response to declining gasoline demand, domestic production of diesel, jet fuel, naphtha, heavy fuel oil, and other products is also affected, despite some scope for adjustment through plant operation and product yields.

A demand transition in one petroleum product can therefore reduce domestic reserve capacity for another and increase import dependence. Lower refinery utilization can also raise production costs. If declining demand leads to rationalization, suspensions, or closures, domestic supply capacity itself may contract.

The way supply and demand are balanced differs by petroleum product (Figure 3-3). Gasoline serves large domestic demand, while imports balance naphtha demand and exports balance diesel supply. Exports of jet fuel and bunker B and C heavy fuel oil also include fueling for international aviation and shipping, recorded statistically as exports under bonded fuel supply, and are therefore different from simple disposal of domestic surpluses. As oil demand contracts, the roles of domestic production, imports, and exports must be redesigned for each product, taking into account the production balance of the refinery as a whole.

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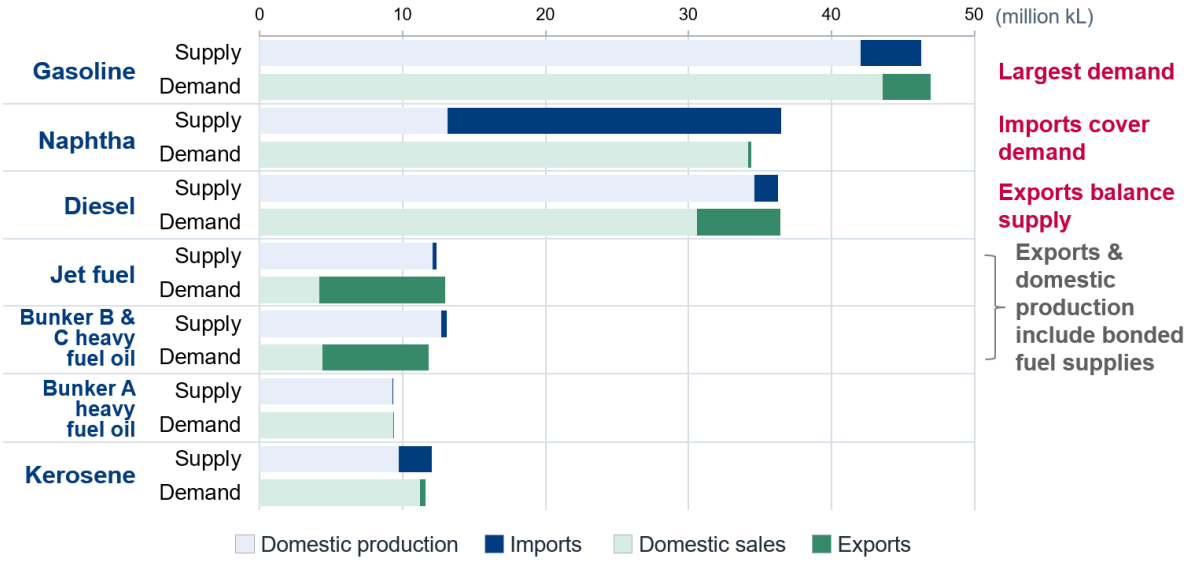


Figure 3-3 Japan's domestic supply–demand structure by petroleum product (2025)

Note: Exports include bonded fuel supply to international aviation and shipping. Export volumes therefore do not necessarily indicate domestic surpluses

Source: Mitsubishi Research Institute, Inc. from the Agency for Natural Resources and Energy's Annual Report on Resources and Energy Statistics 2025 (令和 7 年資源・エネルギー統計年報; in Japanese).

3.2 Transforming the oil supply–demand structure

Even when aggregate oil demand declines, the pace differs by product and use. Some products may consequently be in surplus while others are in shortage. Demand for gasoline and similar products may fall first, while demand in aviation, logistics, and feedstocks are relatively persistent due to a lack of suitable substitutes.

The composition of refinery output, meanwhile, is determined by the properties of crude oil and the combination of distillation, cracking, and reforming facilities. Under these co-production characteristics, large short-term changes in the output of individual products are difficult. If lower utilization caused by declining demand weakens profitability and leads to suspensions, closures, or site consolidation, the domestic reserve capacity for products needed to meet residual demand also falls.

Covering product shortages through imports is likewise constrained by receiving terminals, storage tanks, quality standards, and coastal and land transport. As demand declines, supply capacity supporting residual demand must therefore be redesigned through a combination of imports, stockpiles, domestic refining, logistics, and facility conversion. At domestic refining and petrochemical sites in particular, the priority should be greater flexibility to handle diverse feedstocks and products, rather than maintaining processing capacity as such.

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Figure 3-4 Constraints in Japan's domestic oil supply–demand structure

Source: Mitsubishi Research Institute, Inc.

Existing refineries and petrochemical complexes should be redesigned from crude-oil–processing sites into hubs that accept diverse carbon resources and convert them into fuels and chemicals. In the short-term, they should ensure stable supply while accommodating differences in crude properties from light through heavy grades. Over the medium- to long-term, the range of accepted inputs should expand to recycled, biomass-derived, and synthetic feedstocks. This can increase procurement options and reduce dependence on particular crude oils.

Facilities should adopt a staged approach to fraction and quality adjustment to accommodate differences in crude oil properties, co-processing using existing units, and switching carbon sources and feedstocks. Rather than replacing everything at once, a realistic approach would be to build on the existing strengths of a facility while increasing the flexibility to accept diverse feedstocks and adjust the product mix in response to demand.

On the product side, light fractions should be allocated optimally between gasoline blendstocks and petrochemical uses, including naphtha and benzene, toluene, and xylenes (BTX). At the same time, residual demand for middle distillates in aviation and logistics should be supplemented with low-carbon fuels such as sustainable aviation fuel (SAF) and renewable diesel. Fossil-based carbon in chemical feedstocks should also be gradually replaced with recycled, biomass-derived, and synthetic feedstocks.

Such integrated reconfiguration of feedstock, process, and product portfolios can improve the ability to respond to mismatches between product supply and demand as gasoline demand declines, while simultaneously pursuing supply stability, lower carbon emissions, and continuity of domestic fuel and chemical supply (Figure 3-5).

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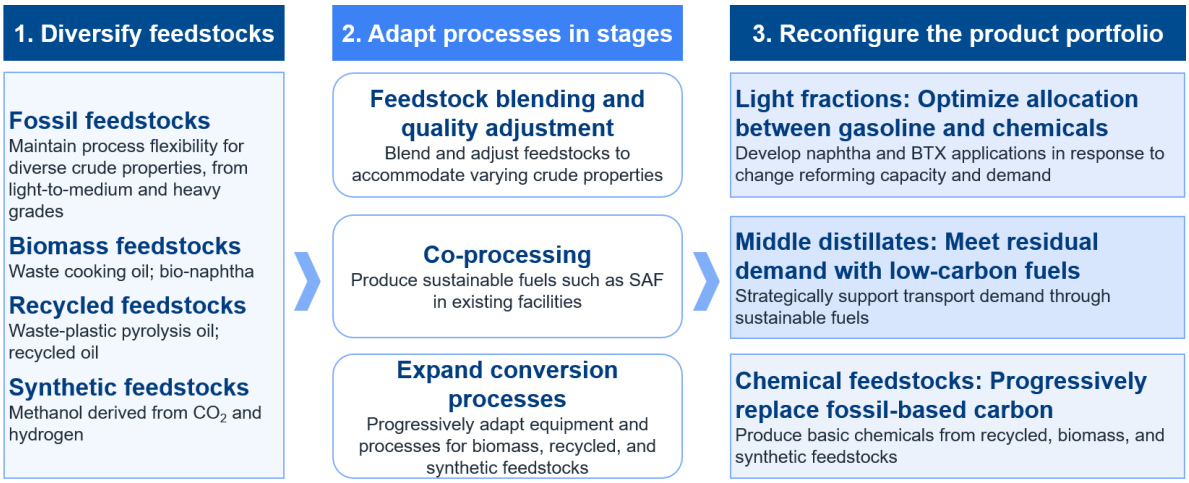


Figure 3-5 Pathways for transforming refineries and petrochemical facilities

Source: Mitsubishi Research Institute, Inc.

The transition to non-fossil fuels should be assessed not only in terms of the carbon emissions of individual fuels, but also in terms of the resilience of the entire supply chain. Merely replacing imported crude oil with imported biofuels or synthetic fuels may simply relocate risks associated with concentration among supplier countries, maritime transport, exchange rates, freight rates, and competition for feedstocks.

To use limited low-carbon fuels and feedstocks and domestic supply capacity effectively, it is first necessary to identify the residual demand that should be secured as a priority and its scale, considering the difficulty of substitution and the social importance of each application. Limited non-fossil fuels and feedstocks should be allocated preferentially to uses such as aviation, shipping, and chemical feedstocks, where electrification or other substitution is difficult and continued supply is important to social and industrial activity. Supply options should then be assessed, looking beyond just life-cycle GHG emissions to the diversification of suppliers and transport routes, stockpiling potential, compatibility with existing facilities, emergency supply volumes, and feedstock sustainability. Imports, domestic production, and local resources should be combined accordingly.

On the basis of these assessments, four responses should be combined: (1) structural transformation of the demand side, (2) domestic production of low-carbon fuels and feedstocks, (3) use of local resources, and (4) diversification of imported feedstocks, products, and routes. Advancing these responses simultaneously is important to prevent decarbonization from creating new dependence on a single source and to strengthen the resilience of the entire supply chain.

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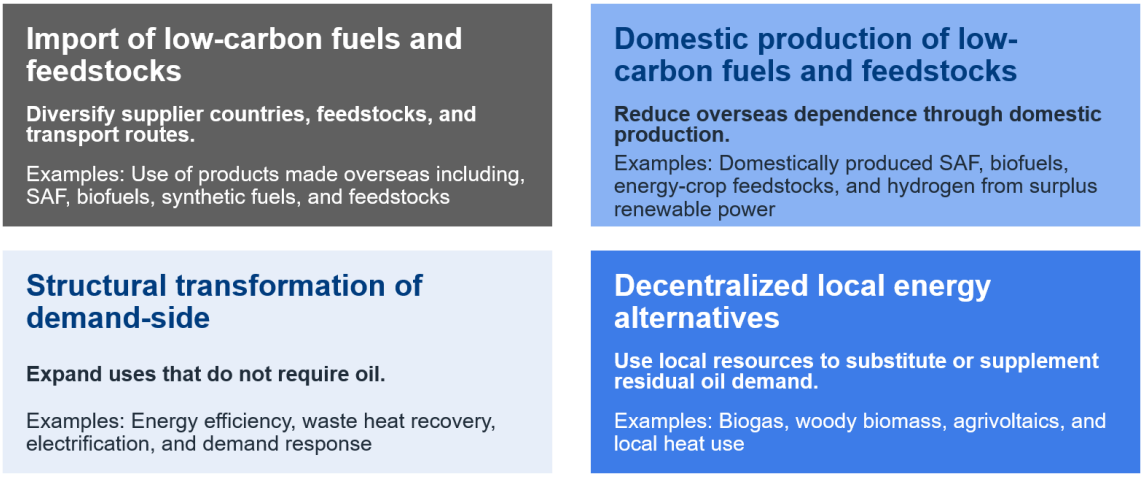


Figure 3-6 Four directions for reducing oil dependence and strengthening supply chain resilience

Source: Mitsubishi Research Institute, Inc.

Redesigning oil supply networks requires selecting supply options anew, starting not only from lower aggregate demand but also from residual demand that differs by application and product. Demand that can be substituted should continue to be reduced or replaced through energy efficiency, electrification, and fuel switching. For critical applications where substitution is difficult, such as aviation, trunk-route logistics, chemical feedstocks, and disaster response, essential residual demand and required volumes should be identified. The country should also use normalcy to diversify crude oil suppliers, product suppliers, and transport routes while removing receiving constraints at ports and tanks.

At the same time, preparations for supply disruptions should include national stockpiles, private-sector stockpiles, and joint stockpiles with oil-producing countries as well as continued international cooperation such as through the International Energy Agency (IEA) and using normalcy to establish procedures for alternative procurement and supply switching. During crises, stockpile releases, international sharing, alternative procurement, and demand restraint should be combined, with concrete rules for giving priority to critical uses when supply is limited.

Preserving future options also requires retaining scope to convert refineries and petrochemical facilities, testing practical implementation through demonstrations of options such as SAF, biofuels, and synthetic fuels, and developing the arrangements needed to receive and use them. Neither uniformly retaining all existing facilities nor uniformly reducing them in line with declining demand is appropriate. Decisions on which functions to maintain domestically and which to convert to future uses must be made progressively, considering residual demand, commercial viability, progress in alternative supply, and conversion lead times.

In August 2026, the Agency for Natural Resources and Energy gave priority to concrete policy design for diversifying crude oil, other procurement sources, and transport routes as well as for stockpiling oil. Maintaining domestic refining and manufacturing capacity and adapting facilities to diverse petroleum products and feedstocks were positioned as subsequent issues.[20] In light of these policy developments, the next focus should be specifying the supply functions that must be maintained domestically, their scale,

[20] Ministry of Economy, Trade and Industry, "Draft Issues for Structural Responses to Ensure Stable Resource and Energy Supplies in Light of International Developments" (国際情勢を踏まえた資源･エネルギーの安定的な確保のための構造的対応に関する論点整理案; in Japanese) https://www.meti.go.jp/shingikai/enecho/shigen_nenryo/sekiyu_gas/supply_structure/002.html (accessed 7 September 2026)

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and the period for which continuity of supply must be ensured, using hard-to-substitute residual demand as the basis. This should be in tandem with stronger procurement and stockpiling too.

The key is to use normalcy to prepare these measures in parallel rather than implement them sequentially. Demand reduction and procurement diversification should continue, while procedures for activating stockpile releases, international sharing, alternative procurement, and demand restraint should be prepared for when emergency strikes. At the same time, the domestic functions to be maintained or converted to future uses should be reviewed continuously against residual demand, commercial viability, and progress in alternative supply.

	Strengthening the supply foundation: Action now prevents future regret	Emergency response: Prepare for contingencies	Preserve conversion options: Keep future options open
Actions in normalcy	• Continue demand reduction and fuel substitution • Diversify suppliers and supply routes for crude oil and petroleum • Eliminate constraints on receiving capacity at ports and storage terminals • **Identify critical residual demand that is difficult to substitute and quantify required supply volumes**	• Maintain and utilize national stockpiles, private-sector stockpiles, and joint stockpiles with oil-producing countries • Continue international cooperation through the IEA and other frameworks • Establish alternative procurement and supply-switching procedures • **Define priority-supply and demand-restraint rules for critical uses**	• Preserve conversion options at refineries and petrochemical facilities • Demonstrate SAF, biofuels, and synthetic fuels, and develop the infrastructure needed to receive them • **Clarify criteria for maintaining or converting domestic supply capabilities**
Guiding principles	**Monitor residual-demand indicators and periodically reassess the degree of measures.**	**In the event of supply disruptions, combine stock releases, international coordination, alternative supply, and demand restraint.**	**Make phased decisions on asset retention and conversion in line with residual demand.**

Figure 3-7 Maintaining and transforming oil supply system in light of residual demand

Source: Mitsubishi Research Institute, Inc.

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4. Decentralized resilience through local resources

Energy autonomy requires not only stronger nationwide networks for power and fuel supply, but also decentralized preparedness that helps maintain critical local functions during emergencies. Geographic dispersion is a feature of heat demand, agriculture, forestry, fisheries, waste and wastewater treatment, emergency shelters, medical care, and logistics. When supply networks are severed, centralized supply alone faces the risk of being insufficient. Biomass and land that go unused locally are important options for complementing nationwide supply capacity.

On their own, these local resources cannot replace the country's imported energy. They can, however, provide solutions to local challenges when combined with energy use, effective in fields such as waste treatment for unused biomass and farmland management for underutilized land. We have put together ways for Japan to develop local resources as a foundation for resilience in both normalcy and emergency: operating them as viable businesses in normalcy and using them as complementary resources that support minimum local functions in emergency.

4.1 The value of unused local resources in normalcy and emergency

The value of unused local resources lies in their multifaceted nature, supporting both day-to-day business operations and emergency functions. Wet biomass, including livestock manure, food waste, and sewage sludge, can yield biogas through anaerobic digestion and fertilizer nutrients from digestate. Dry biomass, such as woody residues, rice straw, and rice husks, can be used for heat, electricity, and fuels through combustion, gasification, and other processes.

In normalcy, businesses can be made viable by combining multiple revenue streams and benefits: lower waste treatment costs, electricity sales and heat supply, fossil-fuel substitution, and recovery of fertilizer nutrients. Crisis is not the situation in which businesses should be trying to set up shop: collection routes, treatment facilities, operators, and customers. Arrangements must first function continuously in normalcy.

During emergency, the same businesses can switch operations to prioritize local shelters, medical and welfare facilities, water and wastewater systems, and agricultural facilities. They can supplement electricity, heat, fuel, and fertilizer supply and help sustain critical local functions. Local resources should be positioned not as replacements for main energy supplies, but as decentralized complementary resources that prevent failures at the ends of supply networks.

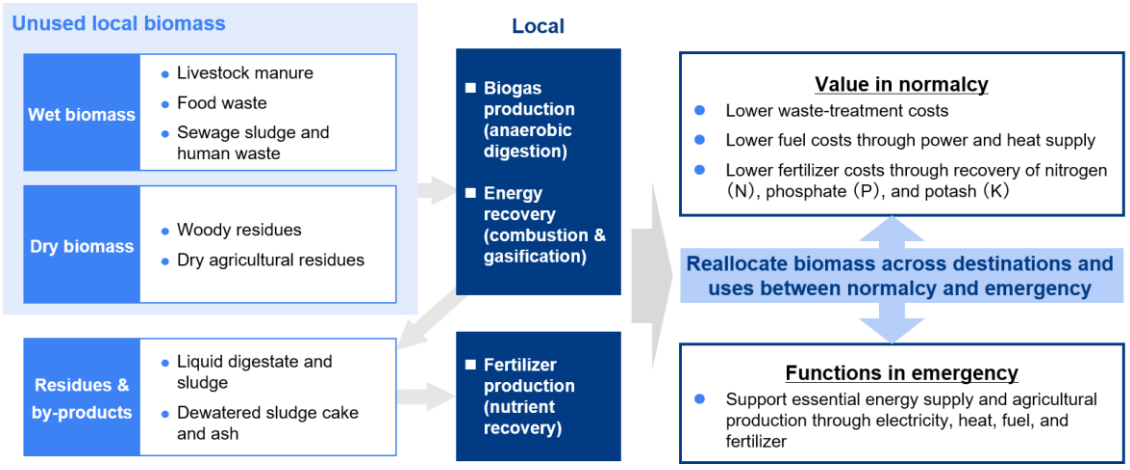


Figure 4-1 The value of unused local resources in normalcy and their functions in emergency

Source: Mitsubishi Research Institute, Inc.

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4.2 Local sources of biomass remain untapped

Wet biomass, when converted into biogas through anaerobic digestion, can serve as both local energy in normalcy and a decentralized source of complementary energy during emergency, supporting local heat and electricity demand.

We have estimated the biogas production and energy potential from anaerobic digestion of wet biomass comprising livestock manure (cattle and pig manure and urine), sewage sludge, septic tank sludge, food waste, food and paper waste within municipal waste, and agricultural residues such as vegetable scraps. We excluded poultry manure as its low moisture content and high calorific value mean that incineration with heat recovery is commonly used in Japan. Municipal waste is limited to household food and paper waste suitable for dry anaerobic digestion, rather than all incinerated waste. Agricultural residues cover vegetable scraps and similar materials statistically classified as other agricultural residues.

The annual quantities of wet biomass covered by our estimates are approximately 65.24 million tonnes of livestock manure from cattle and pigs; 2.60 million tonnes of sewage sludge (dry weight); 140,000 tonnes of septic tank sludge (dry weight); 14.26 million tonnes of food waste; 11.52 million tonnes of food and paper waste within municipal waste; and 230,000 tonnes of agricultural residues (dry weight). Anaerobic digestion of all these quantities would yield approximately 172 PJ/year of energy.

Some of these materials are already used as feed, compost, recovered sewage-sludge resources, and cement feedstocks and fuels. Excluding existing uses, the additional available potential for energy use is estimated at approximately 9.49 million tonnes of livestock manure from cattle and pigs; 1.13 million tonnes of sewage sludge (dry weight); 140,000 tonnes of septic tank sludge (dry weight); 1.77 million tonnes of food waste; 11.29 million tonnes of food and paper waste within municipal waste; and 230,000 tonnes of agricultural residues (dry weight). Anaerobic digestion of these quantities would yield approximately 66 PJ/year, equivalent to about 0.4% of Japan's primary energy supply of 17,461 PJ/year.[21] As an indication of scale, this is approximately 30% of the 238 PJ/year consumed by Japan's agriculture, forestry, and fisheries sectors.

Anaerobic digestion retains most plant nutrients, including nitrogen, phosphorus, and potassium, in the digestate even after carbon has been recovered as energy. Digestate from the additional available wet biomass is estimated to contain approximately 223,000 tonnes of nitrogen, 221,000 tonnes of phosphate (P2O5), and 63,000 tonnes of potash (K2O). Japan's current chemical fertilizer demand[22] is 338,000 tonnes of nitrogen, 273,000 tonnes of phosphate, and 210,000 tonnes of potash (K2O). The theoretical nutrient potential is therefore equivalent to approximately 66%, 81%, and 30% of current chemical fertilizer demand, respectively. Wet biomass can thus provide not only energy, but also an alternative to chemical fertilizers that are highly dependent on imports. It demonstrates strong potential to contribute to stronger local energy and food resilience.

These theoretical potentials assume that all additional available biomass undergoes anaerobic digestion. The practically available potential is constrained by collection and transport conditions, facility locations, and the spatial matching of supply and demand.

[21] Agency for Natural Resources and Energy, "Energy Supply and Demand Results for FY2024 (Final)" (令和 6 年度(2024 年度)エネルギー需給実績(確報); in Japanese) https://www.enecho.meti.go.jp/statistics/total_energy/pdf/honbun2024fykaku.pdf (accessed 7 September 2026)

[22] FAO, World Food and Agriculture - Statistical Yearbook 2025, Table 17 (2023 data) https://farm-d.org/wp-content/uploads/2025/10/cd4313en.pdf (accessed 7 September 2026)

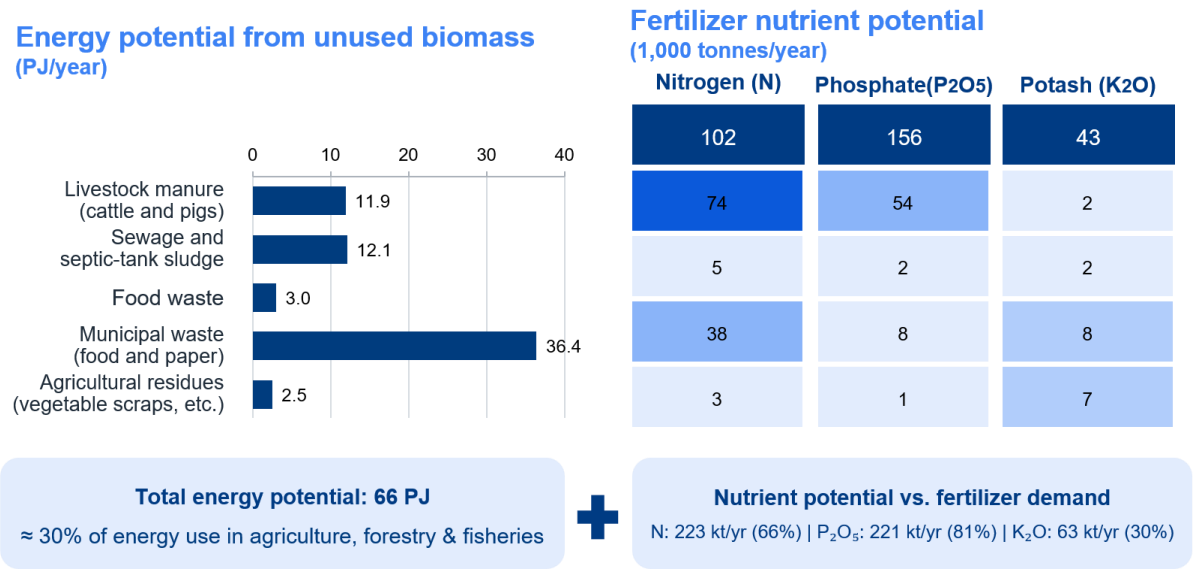


Figure 4-2 Potential of Japan's unused biomass

Note: Underutilized energy potential is a theoretical estimate obtained by excluding quantities already used as fertilizer, feed, cement feedstocks, and other applications, and converting the remaining additional available biomass into energy
Source: Mitsubishi Research Institute, Inc. from various statistical and other materials

Resource potential does not translate directly into practical availability. Unused biomass arises at dispersed locations, with variable quantities, moisture content, and composition. Much is also already used as feed, compost, and cement feedstocks and fuels. Developing small facilities individually can create constraints involving collection costs, utilization rates, operating personnel, and outlets for liquid digestate.

An effective approach is therefore to consolidate and recover resources around existing infrastructure, according to feedstock properties and treatment methods. Plants that treat waste and wastewater can serve as hubs for recovering resources and energy, together treating wet biomass such as livestock manure, food waste, human waste, and septic tank sludge. Combustible and dry residues can instead be consolidated at energy recovery hubs, such as regional incineration facilities, for electricity generation and heat use. Combining these consolidated hubs with local collection of feedstock and use of energy enables efficient use of local resources.

This would (1) stabilize feedstock quantity and quality, (2) improve utilization and profitability through shared facilities, and (3) consolidate operation and maintenance personnel. In FY2024, the energy from sewage sludge was used at a rate of 31% nationwide and 50% in designated cities.[23] There is substantial scope to expand use around existing infrastructure. Excessive concentration, however, creates vulnerability to transport disruptions. A degree of decentralization must therefore be retained by establishing multiple hubs and designating priority recipients during emergencies. We propose an original approach to optimal utilization (Figure 4-3).

[23] Nationwide: 31%; government-designated cities: 50%. Ministry of Land, Infrastructure, Transport and Tourism, "Sewage Sludge Energy Utilization Rate (FY2024 Results)" (下水汚泥エネルギー化率（令和 6 年度実績）; in Japanese) https://www.mlit.go.jp/mizukokudo/sewerage/content/001990855.pdf (accessed 7 September 2026).

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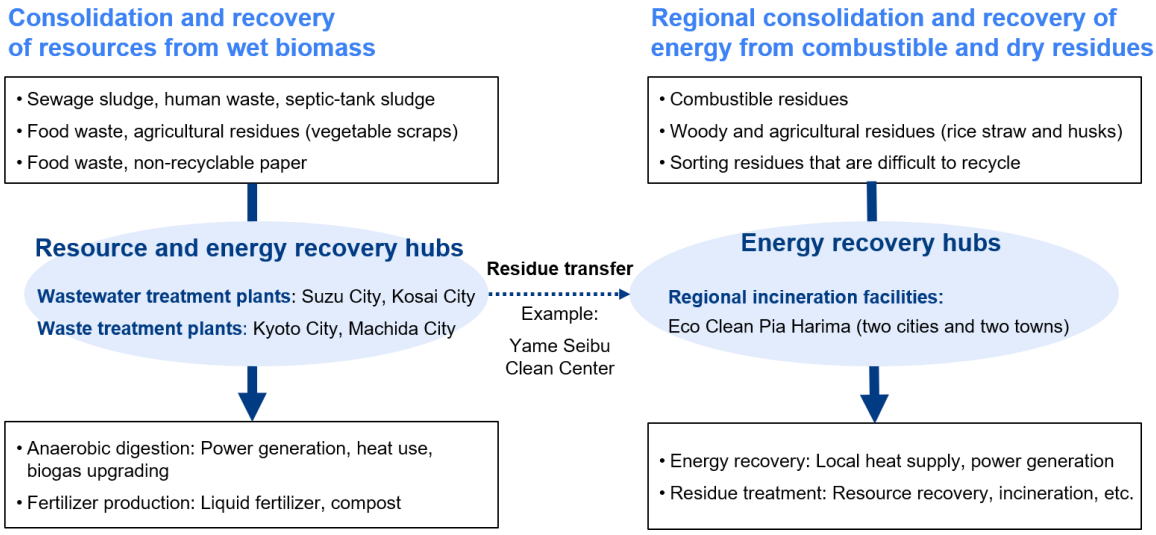


Figure 4-3 Original approach to the optimal utilization of unused biomass

Source: Mitsubishi Research Institute, Inc.

4.3 Local land resources that remain underutilized

Farmland is both the foundation of food production and a local resource that deteriorates if not properly managed, requiring additional expenditure to restore. Japan had approximately 4.23 million hectares of farmland in 2025. At the end of March 2024, abandoned farmland totaled 257,000 hectares, of which 94,000 hectares could be restored to agricultural use.[24]

One option is to combine agrivoltaics and energy crops to generate income for maintenance and management, while giving food production the highest priority. Simply converting farmland into sites for electricity generation is not the objective; it is to create an economic arrangement that allows farming and land management to continue.

We used the approximately 3.5 million hectares of cultivated land estimated in Mitsubishi Research Institute's Long-Term Vision for Food Security to be necessary to maintain today's level of food security in 2050 as the baseline for our analysis (Figure 4-4). We provisionally treated the approximately 700,000-hectare difference from the current cultivated area as land on which multifunctional use could be considered while retaining agricultural use. Adding approximately 100,000 hectares of restorable abandoned farmland gives approximately 800,000 hectares, for which we analyzed the theoretical potential if the land was used as a local resource. If the entire area was devoted exclusively to each use in turn, the potential would be approximately 600 GW of agrivoltaic generation, approximately 1.7 million kL of liquid fuel, or approximately 6.9 million kL of solid fuel on a kerosene calorific-value–equivalent basis. However, these are separate theoretical values without overlapping land allocation and cannot be realized simultaneously.

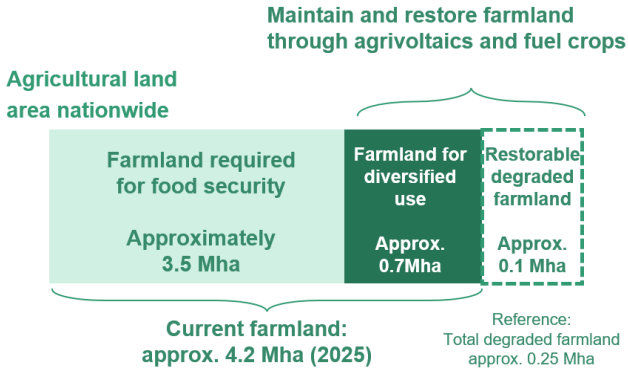
The value of underutilized land should likewise be assessed both by energy output and in conjunction with sustained land use. As population declines and the shortage farmers worsens, integrating energy use as an additional source of income for farmland maintenance and management can prevent land deterioration while increasing local energy supply capacity. Underutilized land use should therefore be positioned less as the use

[24] Ministry of Agriculture, Forestry and Fisheries, "Annual Report on Food, Agriculture and Rural Areas in Japan FY2024" (令和 6 年度 食料・農業・農村白書; in Japanese), Part 1, Chapter 3, Section 2 (May 30, 2025) https://www.maff.go.jp/j/wpaper/w_maff/r6/r6_h/trend/part1/chap3/c3_2_00.html (accessed 7 September 2026).

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of land for energy and more as the integration of energy production into arrangements that keep land under continuous management.

When determining uses for land and biomass, planners must take into account agricultural yields, land conditions, water resources, biodiversity, grid connection, fuel collection, fuel customers, life-cycle GHG emissions, and local consensus. Uses should be combined according to local conditions. For example, agrivoltaics where continued farming and grid connection are feasible could be prioritized, energy crops could be sited near liquid-fuel supply chains, and solid-fuel crops could be put in proximity to local heat demand.



Area assumed for energy potential estimates: Approximately 0.8 million ha

Local energy source / fuel		Theoretical potential
Agrivoltaics		Approximately 600 GW
Fuel crop	**Liquid fuel** Sweet sorghum-derived ATJ-SAF	Approximately 1.7 million kL (About 40% of 2025 domestic jet-fuel sales)
	Solid fuel Erianthus; kerosene energy equivalent	Approximately 6.9 million kL (About 60% of 2025 domestic kerosene sales)

Figure 4-4 Potential for effective utilization of unused local land

Note: We set the conversion factors using various research materials. Agrivoltaic capacity is calculated at 0.75 MW/ha. Liquid fuel uses sweet sorghum at 4.4 kL of ethanol/ha and an alcohol-to-jet SAF yield of 0.48 kL of SAF/kL of ethanol. Solid fuel uses Erianthus at 318 GJ/ha, converted at 36.60 MJ/L for kerosene

Source (land area): Mitsubishi Research Institute, Inc. from Mitsubishi Research Institute, Inc. Long-Term Vision for Food Security: The State Japan's Agriculture Should Aim for in 2050 (食料安全保障の長期ビジョン　2050 年・日本の農業が目指すべき状態) and Ministry of Agriculture, Forestry and Fisheries Annual Report on Food, Agriculture and Rural Areas in Japan FY2024 (令和 6 年度食料・農業・農村白書); both in Japanese

Source (energy potential): Mitsubishi Research Institute, Inc. from published materials including research materials from the Ministry of the Environment, statistics from the Agency for Natural Resources and Energy, and materials from the National Agriculture and Food Research Organization

Implementation requires identifying target sites in coordination with local plans and farmland banks, and establishing long-term land-use contracts, joint management, and fuel offtake agreements together. The economic and resilience value of land use can be achieved simultaneously by inking, while in normalcy, agreements guiding use during emergency, including priority supply to public facilities, agriculture, and local transport.

Nationwide power and fuel supply, domestic refining and stockpiling capacity, and decentralized local-resource use are complementary rather than substitutes. Unused biomass and underutilized land will not replace a large share of national energy supply, but they can enhance local autonomy by combining energy supply with waste treatment, farmland management, and local industry. Building a multilayered structure that reduces demand, increases domestic supply, and diversifies external dependence while maintaining minimum local functions is what energy autonomy means in an era of crisis.

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5. Conclusions and proposals: Three policy transformations for energy autonomy

Our analysis indicates that strengthening Japan's energy security requires not only stockpiling and procurement diversification, but also transformation of the energy–supply-demand structure itself into one that is more resilient to crisis. We propose the following three policy transformations to achieve energy autonomy.

1) Change the evaluation framework: Adding crisis-time value to energy policy assessment

The value of renewables, nuclear power, reserve thermal generation, domestic refining, stockpiling, and local-resource businesses cannot be fully assessed through market prices or utilization rates under normalcy alone. Evaluation indicators should include additional fossil-fuel costs avoided during emergencies, continuity of supply, substitutability, and recovery capability. These indicators should be incorporated in energy policy, electricity market arrangements, and investment support programs.

Our estimated JPY 1 trillion per year in avoided costs is one figure illustrating that value. It is not a net benefit after deducting the additional costs of each measure. Future work should undertake comprehensive policy assessment, including the frequency and duration of emergencies, facility retention costs, and decarbonization effects.

2) Change contracts and policies: Ensuring continuity of essential supply functions for a defined transition period

While transforming demand helps advance the country’s wider green transformation, demand for fuels and feedstocks that are difficult to substitute will remain for a certain period. Decisions about what to retain—coal-fired power, oil refining, stockpiles, ports, logistics, and sales networks—should not be based simply on capacity or aggregate demand. They should identify the functions needed during emergencies, regional supply constraints, and the timing of alternative technology deployment.

Facilities should not be retained on the assumption of permanent operation. Their required roles, necessary capacity, duration of supply, and conditions for conversion to decarbonization technologies should be specified. This can reconcile energy security and decarbonization along the transition timeline, rather than setting them against each other.

3) Change the unit of planning: Integrating local resource policies and businesses at the regional level

Local resources such as sewage sludge, livestock manure, food waste, agricultural residues, and underutilized farmland cannot replace demand nationwide, but they can support minimum local energy supply during crises.

The benefits of deploying local resources should be assessed not only in terms of energy supply volumes and costs, but also their multiple contributions to waste treatment, land management, fertilizer supply, local industry, and disaster preparedness. To use these resources effectively, policy and the development of facilities, currently divided

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among sectors, should be integrated at the regional level. Coordinated efforts should include wide-area collection of feedstock by multiple municipalities, shared treatment facilities, co-location with energy-consuming facilities. Efforts should also include creation of local resource-circulation infrastructure that is commercially viable in normalcy and remains functional in emergency.

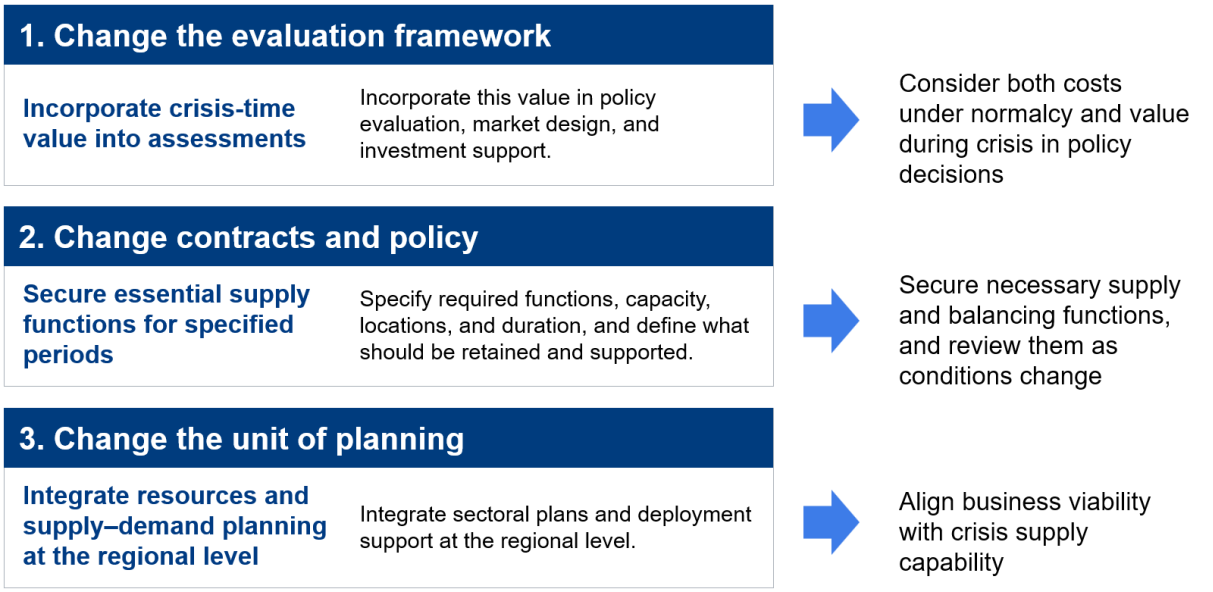


Figure 5-1 Three policy transformations for energy autonomy

Source: Mitsubishi Research Institute, Inc.

Energy autonomy does not mean supplying everything domestically. It means expanding, during normalcy, the options that allow social and industrial activity to continue even when a crisis occurs. Such crisis preparedness should be translated into structural reform of Japan's energy system that simultaneously advances decarbonization, industrial competitiveness, and regional development.

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Authors:

Ishida Hiroyuki, Kuruma Ryota, Saito Yumi, Sakuta Junichi, Nomoto Tetsuya, Furuki Jiro, and Yoshinaga Kyohei

For more information:

Mitsubishi Research Institute, Inc.
10-3 Nagatacho, 2-chome, Chiyoda-ku, Tokyo 100-8141, Japan

General contact:
Center for Policy and the Economy (Tetsuya Nomoto, Hiroyuki Ishida, and Furki Jiro)
Phone: 03-6858-2717 Email: pecgroup@mri.co.jp

Media contact:
Corporate Communications Division
Email: media@mri.co.jp