

# “Inefficient” Locally Produced Biodiesel Effective Following the Great East Japan Earthquake

## 1. Introduction

Almost all commodity distribution systems failed when the Great East Japan Earthquake (hereafter Earthquake) struck the Tohoku region’s Pacific Ocean coast on March 11, 2011. Doi (2014) found that the government was not able to dispatch relief food supplies as intended, according to their disaster-response plan; Doi (2014) pointed out that the delay resulted from a shortage of trucks and fuel at that critical time. Doi (2014) himself engaged in the delivery of relief foods for the Ministry of Agriculture, Forestry, and Fisheries during that crisis, and was responsible for purchasing food and hiring trucks. He reported that food companies produced the merchandise that had been ordered, however, there was a severe shortage of delivery trucks, so the Japan Self-Defense Force (JSDF) carried the food to stocking centers in the Iwate, Miyagi, and Fukushima prefectures. Doi (2014) also commented that carrying relief supplies was not the mandated responsibility of the JSDF, so their involvement indicates the failure of the government’s plan to distribute relief goods during crises. The JSDF was engaged in rescuing people from critical situations, so distributing relief supplies could have disrupted their operations. Although no hunger occurred as a result of the Earthquake, the breakdown of the food distribution system could be more catastrophic in the future, if an earthquake were to strike a more populated area. Consequently, the relief goods distribution problem during the aftermath of the Earthquake raised a very serious problem regarding social security and the food system.

Doi’s (2014) analysis helps to clarify market behaviors during emergency situations, because his analysis is based on documents the government prepares when it

orders food and trucks; the government acquires the food and trucks for the usual price, so we can say that all these activities involve regular purchases at market prices by the government. Thus, from a theoretical point of view, Doi (2014) assessed “how the market did not work,” and his comment—that the government should adopt a policy to ensure the preparation of food and the availability of trucks during a disaster—is reforming related markets. In other words, experiences after the Earthquake established the fact that the market oriented food system is not adequate to maintain social security. Mitsuishi (2011) wrote that small stores on the traditional shopping streets continued to be open for business when all the supermarkets were closed, and he pointed out that the local food system, which consisted of small-scale food businesses, has resilience during disasters; these discussions on the strength of small food businesses were also intended to indicate that the “market oriented economy is not enough.” Nonaka and Ono (2011) researched emergency goods operations in Iwate prefecture, and analyzed the number of trucks hired by the local government. Nonaka and Ono (2011) also indicated that most gas stations were closed for business during the first ten days after the Earthquake. From this they concluded that since fossil fuels have a centralized distribution system, and the Tsunami that followed destroyed the centralized stocking point, the disaster stopped the distribution of all fossil fuels at same time. Thus, previous research indicated that the “heart of the market did not work,” that “small local businesses worked,” and, as Nonaka and Ono (2011) indicated, locally made biodiesel worked. Locally made fuels (such as traditional firewood and charcoal, and lately biodiesel and biogas) tend to be criticized for being inefficient products, however, the situation created by the Earthquake raises the question as to whether maintaining the viability of locally made fuel is effective in achieving desired social outcomes.

Biodiesel is produced either from virgin vegetable oil, or from used cooking oil. Most biodiesel in Japan is made from used cooking vegetable oil that is collected from local food businesses, and refined by small processors. Since the used vegetable oil

comes from the local food system, biodiesel has a strong link to the local food system, and its ready availability would have ensured that the local food system would be viable during the disaster. However, no research has been conducted on biodiesel in earthquake situations, so the aim of this article is to clarify the status of biodiesel in the Tohoku region immediately following the Earthquake, to compare its availability to that of fossil fuel, and to find evidence that local made biodiesel works as a failproof fuel supply. To achieve this objective, we conducted research on prefectural governments, the trucking association, biodiesel refineries, and consumers' co-ops in Iwate prefecture. We have already published a short paper in Japanese on fuel shortages and biodiesel in regard to earthquake disturbances (Nonaka and Ono 2011). We now have to extend this research and discussion to an international audience, because the Earthquake revealed the weaknesses inherent in the "efficient" centralized market.

## 2. Biodiesel in the Tohoku region

As Kemp (2006) indicated, refining biodiesel from vegetable oil is such a simple process that it can be completed in a home kitchen. Consequently, there are more than four hundred small refineries in Japan. Izumiya et al. (2015) researched 447 refineries, and they estimate that their research includes almost all the refineries. Of these, none uses virgin vegetable oil, because the cost of growing and milling vegetable oil in Japan is too high to be competitive with fossil fuel. All the refineries included in Izumiya et al. (2015) use waste vegetable oil, and these researchers estimated that the quantity of Japan's recycling of biodiesel is around twenty thousand KL annually.

The biodiesel refineries in Iwate prefecture run the business as a non-profit recycling activity; they collect used cooking oil from local restaurants, diners, and food processors. Additionally, handicapped workers perform most of the work involved in

refining biodiesel. Izumiya (2013) indicated that small-scale biodiesel businesses in Japan typically have connections to vocational aid centers for handicapped people, because biodiesel might create some earning potential for vocational aid centers, however it has little potential for achieving the profit-making objectives of ordinary businesses. On the other hand, most jobs in the small biodiesel refineries are simple enough to be completed by handicapped people, so this work is suitable for vocational aid centers. Every vocational aid center completes various kinds of tasks at the same time; the process of refining biodiesel is made up of simple tasks that can be performed in a short period of time, like turning reactors on and putting contents into them, after which the workers spend many hours waiting. Consequently it is easy to add biodiesel refining to their other responsibilities.

City halls usually support the vocational aid centers, however, the latest national policies developed for vocational aid centers are included in market-oriented policies. These policies include phrases such as “not charity,” and “balancing income and expenses,” so even though the aid centers’ biodiesel operations are unprofitable, they still have to be economically viable. Hence, we need to confirm their viability, and clarify their cost structures. To achieve these objectives, we conducted a case study in Shizukuishi town (Iwate).

Table 1 summarizes the costs of refining biodiesel at a vocational aid center in the town of Shizukuishi. This aid center collects used cooking oil from hotels, diners, and small food factories in the neighborhood. It refines biodiesel under contract with the town hall. Based on research we conducted in 2007, we estimated the cost per liter as being 128.2 yen, excluding wages. Although the price of regular diesel at gas stations changes frequently, the biodiesel price in the town is set slightly lower than that for regular diesel, and the average price in 2007 was 110 yen per liter. Table 1 indicates that the total cost is much higher than the selling price in that year. The town hall has a budget for the cost for reactors in Table 1, so that it is able to earn a positive income in

the end. Although the costs in Table 1 do not show positive earnings, this does not mean that biodiesel production is generally inefficient in Japan, if we check Table 1 carefully.

The Shizukuishi town refinery leases the reactor for 630,000 yen per year. This fee is shown in Table 1, as 52.5 yen per liter. This fee is the largest item in the statement, however, if the town could reduce the leasing fee, biodiesel would have positive revenues at a price of 110 yen per liter. The fee for the reactor per liter is based on the total volume of production, which in Shizukuishi is 12,000 L annually. The reactor processes 100 L at one time, so the process is run only 120 times a year. If the town produces more biodiesel, the cost will decrease; actually, the Iwate co-op that we discuss later produces much more biodiesel, and they commented that their fee for the reactor is much lower than the fee shown in Table 1. Vocational aid centers have limited staff, so they have limits on their biodiesel production. The Shizukuishi town hall regards its budget for paying the reactor fee as fair enough. Izumiya (2013) indicates that most small biodiesel refineries receive support from their city/town hall, because their business size is limited. On the other hand, as Kemp (2006) showed, the function of a reactor is very simple, and basically involves mixing and heating, so that to make one's own reactor is possible. For example, the Akita trucking company (Akita prefecture, Tohoku region) produced biodiesel for its trucks using their hand-made reactors. If the town of Shizukuishi reduced its fee for the reactor, by doubling its production of biodiesel, or using a homemade reactor, then the costs of running the plant shown in Table 1 would match the plant's earnings. However, workers would still be unable to earn regular wages. In the first place, unlike fossil fuels, recycled biodiesel does not satisfy strict regulatory requirements, so it is not treated like a regular commodity. Izumiya (2013) indicates, and the town of Shizukuishi uses the same system, that city/town halls usually purchase a significant part of the biodiesel fuel, and the rest is used for local consumption. Vocational aid centers have many types of vehicles, and they usually have trucks and buses that are able to adapt to running

biodiesel. If we consider a city/town hall's consumption as being the community's consumption, the aim of refining biodiesel becomes making fuel for their own use. This self-sufficiency is the second condition that keeps biodiesel economically viable. Thus, we have to say that biodiesel is not part of the national fuel market. However, being self-sufficient represents a considerable part of the local economy, as Nonaka and Ono (2015) indicate, so that it would vitalize the rural economy. Moreover, biodiesel played an important role in the aftermath of the Earthquake.

### 3. Fuel shortages after the Great East Japan Earthquake, and the delivery of relief goods in Iwate prefecture

The Earthquake disturbed all kinds of commodity distributions in the eastern part of Japan, and especially so in the Tohoku region, for almost a month. The Tsunami struck the Pacific coastline of the Tohoku region (Iwate, Miyagi, Fukushima prefectures), and commodity distribution systems there were severely damaged. Iwate prefecture is located on the north Pacific side of the Tohoku region, and the Tsunami struck and seriously damaged the entire seaward area. The prefectural government initiated relief operations immediately after the Earthquake. Table 2 summarizes the relief goods that the Iwate prefecture gathered in the first ten days. Most of the relief goods were food and water, and it is apparent that the operation really involved providing supplies needed to sustain life. Table 3 summarizes the number of trucks that were dispatched from the prefecture's capital city of Morioka to coastal areas. It shows that the JSDF delivered relief goods immediately following the Earthquake, after which the prefectural government assumed a decisive role in delivering relief goods.

As Doi (2014) showed, even the central government took two to three days to prepare the first supply of relief goods for the Tohoku region. The prefectural

government was responsible for distributing relief supplies from storage sites in the prefectural capital to coastal areas, however, it initially needed time to get organized, so the JSDF delivered the relief goods instead. The prefectural government began distributing supplies on March 14, after which it assumed a central role, as Table 3 shows. The operators and trucks of the prefectural government shown in Table 3 are truck drivers from the Iwate Trucking Association. This association has a contract with the Iwate prefectural government to provide assistance in cases of disaster.

The operations summarized in Table 3 represent the most decisive days, however it was a very difficult task because the delivery of all fossil fuels had been stopped, because they are produced outside the Tohoku region, and the Earthquake and Tsunami destroyed all of the region's distribution routes. The Iwate prefectural government got the fuel from local vendors' inventory, as part of their relief goods, and provided it to the Iwate Trucking Association. Some of the association's trucks were not able to get fuel. Table 4 summarizes the results of telephone research conducted by the Tohoku Bureau of Economy, Trade, and Industry on gas stations in Iwate prefecture during the relief goods distribution operation. This table shows that the researchers phoned 599 gas stations, but fewer than half of the stations responded. This suggests that the stations that did not respond to the calls were closed. Among those that responded, almost half were open during the day, but most of them supplied fuel only for emergency vehicles, which included ambulances, fire engines, and prefectural government trucks. Table 4 indicates that it was almost impossible for regular customers to purchase gas and diesel at the market.

The Iwate prefectural government had provided fuel to the Iwate Trucking Association until April 5, because there continued to be a daily shortage of fuel. Table 5 shows the total number of truck-days in Table 3, and the average number of trucks active over the ten days. Table 5 shows that the prefectural government operated about 31 trucks a day. These trucks are small to midsized trucks, since larger trucks could not

travel on the damaged roads, because roads in coastal areas were narrow, and people had to remove rubble manually to open them to traffic (see Picture 1).

#### 4. Biodiesel for the delivery of relief goods

During the fuel shortage, the prefectural government obtained fuel by issuing administrative directives. Details of the trucking operation are summarized in Tables 3 and 5. However, the operation was still constrained by the quantities of fuel that the government was able to purchase. The Chairman of the Iwate Trucking Association commented that his Association needed fuel even more urgently than it needed more operating trucks (than those shown in Tables 3 and 5), because moving materials from storage near the prefectural government's office to the coastal area required various kinds of commodities' distribution capabilities. Truckers had to drive to the factories and depositories to pick up the goods and take them to the stocking point. Doing so required many more trucks than those shown in Tables 3 and 5. The Chairman commented that they dispatched as many trucks as they could, but this number was smaller than they had expected it would be, based on their contract with the prefectural government.

Due to the fuel shortage, there was no non-governmental operation to carry relief goods to coastal areas except for the Iwate co-op. This co-op also experienced serious fuel shortages, however they had access to biodiesel.

The Iwate co-op is a consumers' co-op that serves the entire Iwate prefecture. It has about two hundred and ten thousand members, who represent almost 41% of all households in the Iwate prefecture. Since the coastal area is included in their business area, responding to the people's needs after the Tsunami was the co-op's top priority. However, they were unable to send goods using fossil fuels, but they had stored

biodiesel, and some materials for producing biodiesel at their refinery in Morioka city. Table 6 summarizes the Iwate co-op's activities in relation to biodiesel. It shows that they started collecting biodiesel two days after the Earthquake. They produced biodiesel at their refinery, and also asked several friendly refineries to donate biodiesel. Most of the refineries in Iwate prefecture are involved with a vocational aid center for handicapped people called "Sanseien," and the biodiesel donations the co-op received were based on this connection. Sanseien, in Morioka city, pioneered the involvement of vocational aid centers with biodiesel in Japan. The center is often described in journals related to handicapped people. Sanseien staff taught anyone who wanted to start a small biodiesel refinery how to produce biodiesel—including the Iwate co-op and the town of Shizukuishi. Because of this relationship, the Iwate co-op received a total of 1,950 L of biodiesel on the days shown in Table 7—March 14 to 25.

The Iwate co-op was not able to obtain any fossil fuel on these days, so the relief supplies they sent to the coastal areas depended on biodiesel only. The total distance covered was about 11,000 km. The distance from the co-op's headquarters in Morioka to the coastal area is about 120 km, and the fuel consumption of the co-op truck is estimated to be 5.6 km/L, so trucks made a total of 45.3 deliveries.

As Table 6 shows, the Iwate co-op moved many kinds of food to the Tsunami-stricken area, and included rice balls and hot soup prepared by their members, and the co-op's regular retail merchandise (they provided food to everyone regardless of membership). They also contributed some of their merchandise to governmental operations as shown in Table 2. That the various goods sent to coastal areas contributed to the refugees' survival is beyond controversy. The total quantity of fuel shown in Table 7 is very small relative to the usual quantities required, however it is very meaningful when we compare the Iwate co-op's supplies of biodiesel to the prefectural government's trucks in Tables 3 and 4. The average number of trucks hired by the prefectural government on a daily basis was reported to be about 31.1 according to

Table 5. We estimated the Iwate co-op's biodiesel operation as providing the fuel for 45.3 trips/truck to the coastal area. This was more than the average daily number of prefectural government trucks. The Iwate co-op's biodiesel accounted for more than one entire day's travel during the first ten days of the prefectural government's operation.

## 5. Difficulties with Biodiesel in a disaster situation

Since the Iwate co-op's biodiesel is based on local, used cooking oil, the example of the Iwate co-op indicates that the combination of a local food system and a local small-scale biodiesel refinery worked as a failproof economic system. However, there was a major difficulty with refining biodiesel during the failure of the fossil fuel distribution. It depends on a supply of methanol. Table 6 indicates that Iwate co-op stopped producing biodiesel on March 25, because they ran out of methanol on that day.

We conducted telephone interviews with Sanseien and the refinery in Shizukuishi on March 14, and both of them informed us that they had stopped refining biodiesel because they ran out of methanol. Sanseien's inventory of biodiesel shown in Table 6 had been stockpiled prior to the Earthquake.

Nationally networked fuel companies distribute methanol. Usually gas stations deal with it as end retailers. On March 14, 2011 we conducted telephone interviews with a fuel company that usually delivers methanol to Sanseien and Shizukuishi. They informed us that all the fuel distribution channels include methanol, and they had been destroyed by the Earthquake and Tsunami, so none remained. The fuel companies' main stocking point is in the coastal area, so the Tsunami destroyed the heart of the fuel supply chain. For safety reasons, small refineries do not stock a quantity of methanol, and when the methanol supply ran out, refining biodiesel was no longer possible. Some new methods refine biodiesel without using methanol, however these methods are not

suitable for small refineries. The Iwate co-op had leftover vegetable oil when they stopped refining biodiesel. As Table 6 shows, they found outdated vegetable oil at a related food depository on March 13, and used it to produce biodiesel. The outdated oil included fresh oil in packages that the Tsunami damaged, so it came from the co-op's regular commodity supplier. Since biodiesel is made from vegetable oil, small local biodiesel refineries and the local food system work together as a failproof food supply system during disasters. Hence, biodiesel is not just providing jobs for handicapped people, but also ensuring that the local food system is failproof.

## 6. Discussion

We have reviewed biodiesel production in Shizukuishi and the relief operation of the Iwate co-op. The Shizukuishi case indicated cost problems; it shows that its high cost is biodiesel's negative feature, since it is an expensive fuel. The Shizukuishi production quantity is so small that the cost of the machines pushes the total cost up beyond the price at which the biodiesel is sold. If production quantities were increased, the cost for the machinery would be lower due to economies of scale. However the cost of methanol, which also comprises a large share of the total cost, does not have this cost advantage, so all small-scale refineries have this costing problem. Methanol costs 48 yen per liter of produced biodiesel. The price of regular diesel in Japan is usually 100 to 120 yen, so that the cost of methanol accounts for almost half of the total cost. This makes biodiesel a less profitable product. The Shizukuishi town example shows that vocational aid centers tend to engage in the biodiesel business because they manage it as an activity for handicapped people, one that is supported by the town hall. The Iwate co-op's biodiesel production has characteristics typical of the recycling movement. It has much larger production quantities, so its production costs are much lower than those

in the town of Shizukuishi, however, the high cost and low profit problem still exists, because the Iwate co-op pays the same price for methanol that the town of Shizukuishi pays. The high cost and low profit of biodiesel prevents fuel related companies from moving into the biodiesel business; it is also the reason that biodiesel remains a very minor fuel in Japan.

Even small biodiesel refineries based on the local food system depend on methanol, which is supplied by fossil fuel retailers. As we saw in the case of the Iwate co-op, obtaining methanol is a bottleneck for biodiesel refineries that work as a part of a local food system, and failproof the fuel system against disasters. Its dependence on methanol is the second negative feature of biodiesel. As we saw in the Iwate co-op's case, the co-op produced biodiesel until it ran out of stocked methanol. The co-op made a great contribution as a relief operation, however, the fact that it stopped producing biodiesel when it ran out of methanol is evidence that biodiesel is not completely a local fuel.

On the other hand, the Iwate co-op's case indicated that biodiesel and the local food system worked together to ensure the survival of people in the coastal area. The Iwate co-op dispatched trucks to carry many kinds of food, as shown in Table 6. Nation-wide networked supermarkets were not open for business during the Iwate co-op's operation, and the Iwate co-op is the only food system that worked at that time. Doi (2014) indicated that the central government was not able to dispatch adequate food supplies to seriously damaged prefectures in the first ten days, and this delay in the relief operation resulted primarily from a shortage of trucks. Doi (2014) pointed out that the JSDF moved 40% of the food supplies to the prefectural stocking point, and this activity was not part of the disaster relief operating plan. Doi (2014) also noted that the JSDF's efforts are evidence that the government was not able to complete the relief food operation by hiring trucks and purchasing fuels (in short, markets), and he warned that if the disaster had occurred in a more populated area, it could have been a more

catastrophic situation. Our research also clarified that prefectural governments had difficulties dispatching trucks to seriously damaged areas. This is further evidence that the so-called “effective” fossil fuel market was not able to ensure people’s survival in Tsunami-stricken areas. People became aware that implementing the government’s preparations for disasters is an urgent matter, and making local economies failproof should be one of its basic objectives. Biodiesel is “ineffective” compared to fossil fuels. If we focus on the costs and prices, however, it was effective in the aftermath of the Earthquake, and it enabled the local food system to be failproof. Although methanol problems limit biodiesel’s potential as a failproof fuel, the Iwate co-op case indicates that biodiesel is a failproof fuel when fossil fuels are not available, because it is produced locally and is linked to the local food system. The latest market-oriented policies tend to criticize products with low profitability—such as biodiesel and firewood—or co-operative movements, however these products and networks are characteristically based on small-scale local production, so they have a better chance of surviving disasters compared to centralized production and distribution systems.

## 7. Conclusion

The aim of this article is to clarify the status of biodiesel in the Tohoku region immediately after the Earthquake to that of fossil fuel, and to document any evidence showing that locally made biodiesel worked as a failproof fuel supply. We considered the role of the small-scale biodiesel refinery in the town of Shizukuish, the production costs of biodiesel, and why vocational aid centers tend to be engaged in biodiesel. In doing so, we saw how important biodiesel was in the Iwate co-op’s Earthquake relief operation. The Shizukuisi town case showed that biodiesel cannot be regarded as a normal commodity, because it is hard to ensure its profitability. The Iwate co-op’s case provides evidence that locally made biodiesel works as a failproof fuel supply when combined with the local food system. Although methanol supplies define biodiesel

refining, the Iwate co-op produced biodiesel for twelve days, and the worth of this fuel exceeded one day of the prefectural government's operation. We therefore conclude that biodiesel provided an effective emergency fuel supply. This fact strongly infers the limited reliability of a centralized market, and the need to promote the development of local products.

The cost problem described earlier precludes the likelihood that biodiesel will become a major fuel in the total fuel market. On the other hand, as this article showed, biodiesel demonstrated resilience in the disaster described, and the disaster revealed fundamental weaknesses in the fossil fuel supply. Biodiesel's strengths were shown to be the product of a small-scale production, a local base, and being integrated with the local food system. Our analysis leads to the conclusion that other local fuels and local products could potentially also contribute to a failproof economic system; however, this hypothesis has to be clarified with additional research. As such, it remains a problem.

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