Kyoto – Japan

Usage of Recycled Cooking Oil as an Alternative Fuel for Transportation

Environment Bureau

City of Kyoto, Japan
Reclaimable, alternative fuel for light oil from waste edible oil.
Resource recycles of waste edible oil from general households as well as restaurants and cafeterias.
What prompted biodiesel fuel production in Kyoto is ...

Kyoto Conference on the Prevention of Global Warming (COP3) held in December 1997
## Estimated potential waste edible oil recovery and BDF usage rate per year in Kyoto

<table>
<thead>
<tr>
<th>Source of Discharge</th>
<th>Estimated Potential Recovery</th>
<th>Annual Usage</th>
<th>Utilization Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharged from general household</td>
<td>about 1,500KL</td>
<td>about 150KL</td>
<td>about 10%</td>
</tr>
<tr>
<td>Discharged from restaurants and cafeterias</td>
<td>about 3,000KL</td>
<td>about 1,500KL</td>
<td>about 50%</td>
</tr>
</tbody>
</table>
Placement of collecting points of waste edible oil from households and progress of collecting volume of the oil

The aim in placement of the collection points is 2000 points (one point for each 300 families)

Partnership with citizens, companies and municipality

Citizen who have a keen awareness of environmental issues

Expand to local communities, regional women societies etc.

bush telegraph of citizen who have a great zeal for environmental matters

Neighborhood Garbage-reduction Promotion Councils (model tests collecting) 13 Points

Waste edible oil from households in Kyoto has been recovered as a grass-roots activities

Collecting points and collecting volume of waste edible oil from households

<table>
<thead>
<tr>
<th>Year</th>
<th>Collecting Points</th>
<th>Collecting Volume (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>4,265</td>
<td>73</td>
</tr>
<tr>
<td>1998</td>
<td>22,731</td>
<td>2,75</td>
</tr>
<tr>
<td>1999</td>
<td>62,445</td>
<td>531</td>
</tr>
<tr>
<td>2000</td>
<td>95,747</td>
<td>602</td>
</tr>
<tr>
<td>2001</td>
<td>116,019</td>
<td>693</td>
</tr>
<tr>
<td>2002</td>
<td>123,032</td>
<td>1,281</td>
</tr>
<tr>
<td>2003</td>
<td>128,118</td>
<td>1,181</td>
</tr>
<tr>
<td>2004</td>
<td>125,276</td>
<td>864</td>
</tr>
<tr>
<td>2005</td>
<td>127,158</td>
<td>956</td>
</tr>
<tr>
<td>2006</td>
<td>149,382</td>
<td>1,013</td>
</tr>
</tbody>
</table>

Quantity (L) - {}
Collecting system: Polyethylene collection-tank system

Collecting system: Permanent point and drum system
Issues on Citizen collection

① Drop in increasing rate of collecting points
   ⇒ Foundation of subsidy system

② Drop in increasing rate of collecting oil
   ⇒ Setting up permanent collecting points

③ Decrease of opportunity to make tempura at home
   Declining birthrate and a growing proportion of elderly people. Increase of chance to eat snack
   ⇒ Tap new collecting targets

④ Protection of personal information and exhibition of the collecting points
   ⇒ Confirmation of public consent for exhibition
Kyoto Municipal Waste Edible Oil Fuel Production Facility  5000 liters/day
Supporting Project of Ministry of Environment
Panorama of Production Process

Three-tank construction

(1. Pretreatment tank  2. Reaction and separation tank  3. Refinery tank)
It is easy to produce Biodiesel Fuel, but ...  
Raising reaction rate (high esterification) and high removal of impurity or water is essential!

Experiment set  
methanol input  
double-boil 60°C mixture agitation

rough methyl ester impurity remains  
glycerin  
reactive separation
remained glycerin and potassium (catalyst) ⇒ stains fuel filter and engine inside

highly viscous accumulated matter (bottom of TCV hole)

fuel filter clogging
Influence with the use of biodiesel fuel to diesel vehicles

1. Influence to fuel supply system
   ① fuel element clogging ⇒ glycerin, Kalium
   ② fuel pipe corrosion ⇒ oxidation (free fatty acid) methanol
   ③ swelling of fuel hose and packing, degradation ⇒ esters

2. Influence to fuel injection system
   ① stick and deposit generation in injection nozzle ⇒ unreacted oil (mono, di, tri-glyceride)
   ② defective actuation of injection pump ⇒ glycerin, Kalium
**Major improvement points in production system of Biodiesel fuel**

- **waste edible oil** 【material】
- **methanol catalyst** 【sub-materials】
- **dewatering, decompression** 【pretreatment】
- **reaction** 【primary treatment】
- **methanol recovery** 【primary treatment】
- **separation** 【secondary treatment】
- **cleaning with water** 【secondary treatment】
- **moisture removal** 【third treatment】
- **additives** (improve the fluidity of fuel at low temperatures) 【fourth treatment】
- **biodiesel fuel** 【product】
- **1 μm filter** 【filter】

**Major improvement points in refinery system**

① Methanol reuse by the method of dewatering and decompression. Reduction of remained moisture and methanol

② Reduction of remaining glycerin, alkali metals and absorbent by changing fuel refinery method from dry process to wet process (wash with water).

③ Removal of contaminants by alteration of the filter mesh-size from 5 μm to 1 μm.
### Change of properties with the alteration to fuel production method—Establishment of original fuel standard—

<table>
<thead>
<tr>
<th>Process</th>
<th>① beginning—dry refinery—</th>
<th>② improvement—dry refinery—</th>
<th>③ improvement—wet refinery—</th>
<th>④ facility—wet refinery—</th>
<th>temporary standard of Kyoto city</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature of process</td>
<td>Activated white earth</td>
<td>Pretreatment (filtration, dehydration), activated white earth•silica gel column•centrifugation</td>
<td>Methanol recovery, cleaning with water, aftertreatment (dehydration, pour-point depressant)</td>
<td>Two-stage ester conversion reaction, Two-stage hot water cleaning</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Object year</th>
<th>1998•1999</th>
<th>2001</th>
<th>2002</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content (ppm)</td>
<td>490~735</td>
<td>649~800</td>
<td>300</td>
<td>158</td>
</tr>
<tr>
<td>Flash point (°C)</td>
<td>51~64</td>
<td>32~33</td>
<td>198</td>
<td>172</td>
</tr>
<tr>
<td>Sulfur content (ppm)</td>
<td>2~</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Mono-glyceride (%)</td>
<td>No Measurement</td>
<td>0.57~0.76</td>
<td>0.82</td>
<td>0.73</td>
</tr>
<tr>
<td>Di-glyceride (%)</td>
<td>No Measurement</td>
<td>1.17~1.26</td>
<td>1.31</td>
<td>0.16</td>
</tr>
<tr>
<td>Tri-glyceride (%)</td>
<td>No Measurement</td>
<td>10.16~11.28</td>
<td>7.94</td>
<td>0.03</td>
</tr>
<tr>
<td>Free glycerin (%)</td>
<td>No Measurement</td>
<td>0.059~0.300</td>
<td>0.005</td>
<td>0.006</td>
</tr>
<tr>
<td>Methanol (%)</td>
<td>No Measurement</td>
<td>0.76~0.80</td>
<td>≤0.01</td>
<td>0.012</td>
</tr>
<tr>
<td>Alkali metal (mg/kg)</td>
<td>No Measurement</td>
<td>101</td>
<td>2</td>
<td>2.6</td>
</tr>
<tr>
<td>Remarks</td>
<td>Ash content Decreasing</td>
<td>Enhancement on residual impurities removal such as remaining glycerin</td>
<td>Reduction of un-reacted oil, high esterification</td>
<td></td>
</tr>
</tbody>
</table>
Measure to fuel hoses of biodiesel fuel vehicles

Fuel hoses and packing ⇒ Alteration to string-slot rubber or fluorine rubber
Use of biodiesel fuel to city buses and garbage-collection trucks

City buses (about 95) B20 (containing 20% BDF)

Garbage-collection trucks (about 220) B100 (100%)

The use of roughly 1.5 million liters of biodiesel fuel per year contribute to a reduction in carbon dioxide emissions by about 4000 tons per year.
The present conditions and problems of influence to vehicle

Distinction of Biodiesel fuel

① Vulnerable to low temperature of the winter season
   → improvement on low temperature liquidity is needed

② Easy to be oxidized (occurrence of gum-like product materials)
   → Security of oxidation stabilizer is needed

③ Investigation of long-term influences
   → Continuous confirmation on corrosion of the pipe inside is needed
Mr. Ukyo Katayama has completed Dakar rally using biodiesel fuel (B100) of Kyoto city goal on the 21st of Jan. The general ranking was the 68th place (19th place in class) ~

After the rally, the fuel remained in the fuel tank or in the drum was collected as a sample and taken back. The effects of the fuel additives was analyzed and investigated to make further quality improvement of biodiesel fuel.
## Details of BDF Production expenses in 2005 fiscal year

(yen / liter)

<table>
<thead>
<tr>
<th>Item of expenses</th>
<th>Amount of money</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Management expenses</strong></td>
<td>80</td>
</tr>
<tr>
<td>Purchases cost for waste edible oil</td>
<td>29</td>
</tr>
<tr>
<td>Purchases cost for methanol and catalysts</td>
<td>10</td>
</tr>
<tr>
<td>Water bill (electricity supply is covered by in-house power generation)</td>
<td>2</td>
</tr>
<tr>
<td>Expenses for quality check</td>
<td>8</td>
</tr>
<tr>
<td>Expenses for quality improvement research</td>
<td>8</td>
</tr>
<tr>
<td>Other running costs</td>
<td>23</td>
</tr>
<tr>
<td><strong>Depreciation of facilities</strong></td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

The production expenses is 100 yen per liter including the depreciation of facilities (management expenses is 80 yen per liter). It is almost equal to the light oil price.
Mayor of Kyoto was designated as the chairperson of the national conference for promotion of biodiesel fuel use. The meeting was held in March, 2007, at Minami Aoyama hall, Tokyo.

**Actions for promotion of biodiesel fuel use**

1. Guideline and quality standard for safe and appropriate use of the fuel
2. Study for promotion of the fuel use on a system side like tax abatement
“Kill five birds with one stone”
effects and meanings

① Recycling of waste edible oil
② Cut CO2 emission (about 4000tons per year)
③ Clean the car exhaust gas
  (reduce CO、HC、PM、Sox)
④ Practical environment education
⑤ Activation of local community