

Usage of Biofuels in Thailand and Future Technological Issues

presented at "The 5th JCAP Conference Program"
at Hitotsubashi Memorial Hall,
National Center of Sciences Building,
Tokyo, JAPAN
on February 23, 2007

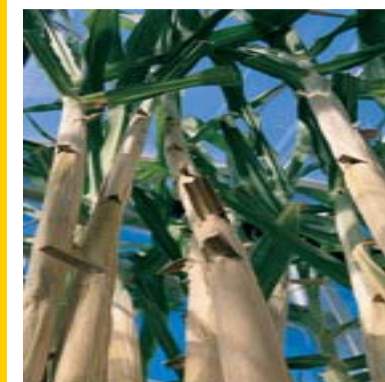
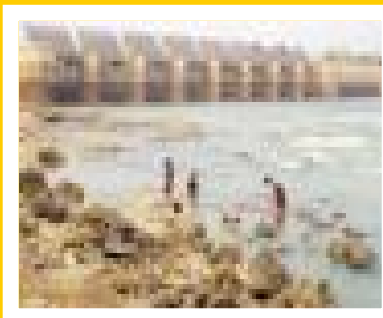
Peesamai Jenvanitpanjakul
Thailand Institute of Scientific and Technological Research
(TISTR)

Presentation Outline

- ☐ Thailand Energy Situation
- ☐ Target of Renewable Energy
- ☐ Fuel Ethanol
 - ☐ Production
 - ☐ Usage
- ☐ Biodiesel
 - ☐ Production
 - ☐ Usage
- ☐ Future Technological Issues
- ☐ Conclusion

Domestic Production of Primary Energy

- ❑ Crude Oil
- ❑ Condensate
- ❑ Natural Gas
- ❑ Lignite
- ❑ Hydro
- ❑ New and Renewable Energy



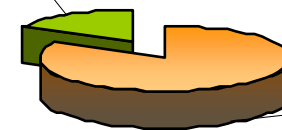
Energy Situation in Thailand

- + Local fossil fuel are limited**
- + Inadequate to meet the national energy demand**
- + Oil price increasing**
- + In 2004, energy consumption \$ 28.75 billion or 15.7% of GDP**
- + Rely on import energy, \$ 18.8 billion in 2005**

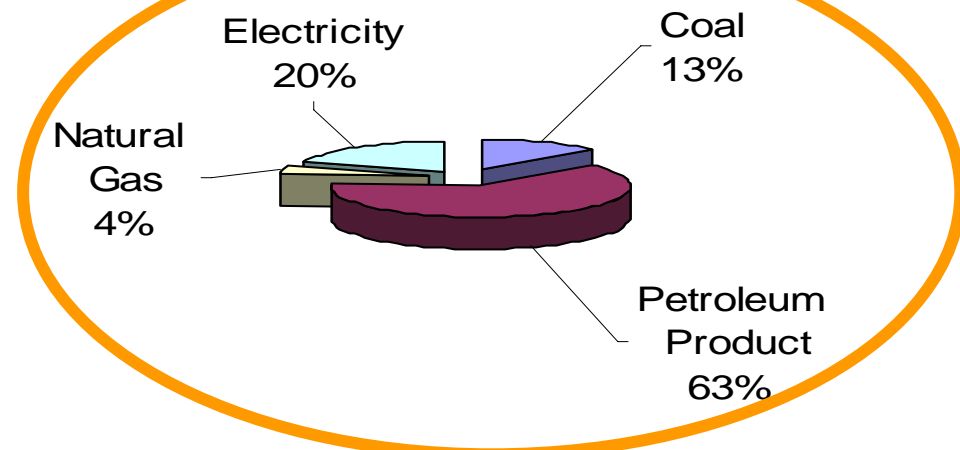
Final Energy Consumption by Type (ktoe)

| | |
|----------------------------------|--------|
| Commercial Energy | 51,571 |
| Coal | 6,755 |
| Petroleum Product | 32,460 |
| Natural Gas | 2,026 |
| Electricity | 10,330 |
| New & Renewable Energy | 10,824 |
| Total Energy Consumption by Type | 62,395 |

NRE
17%



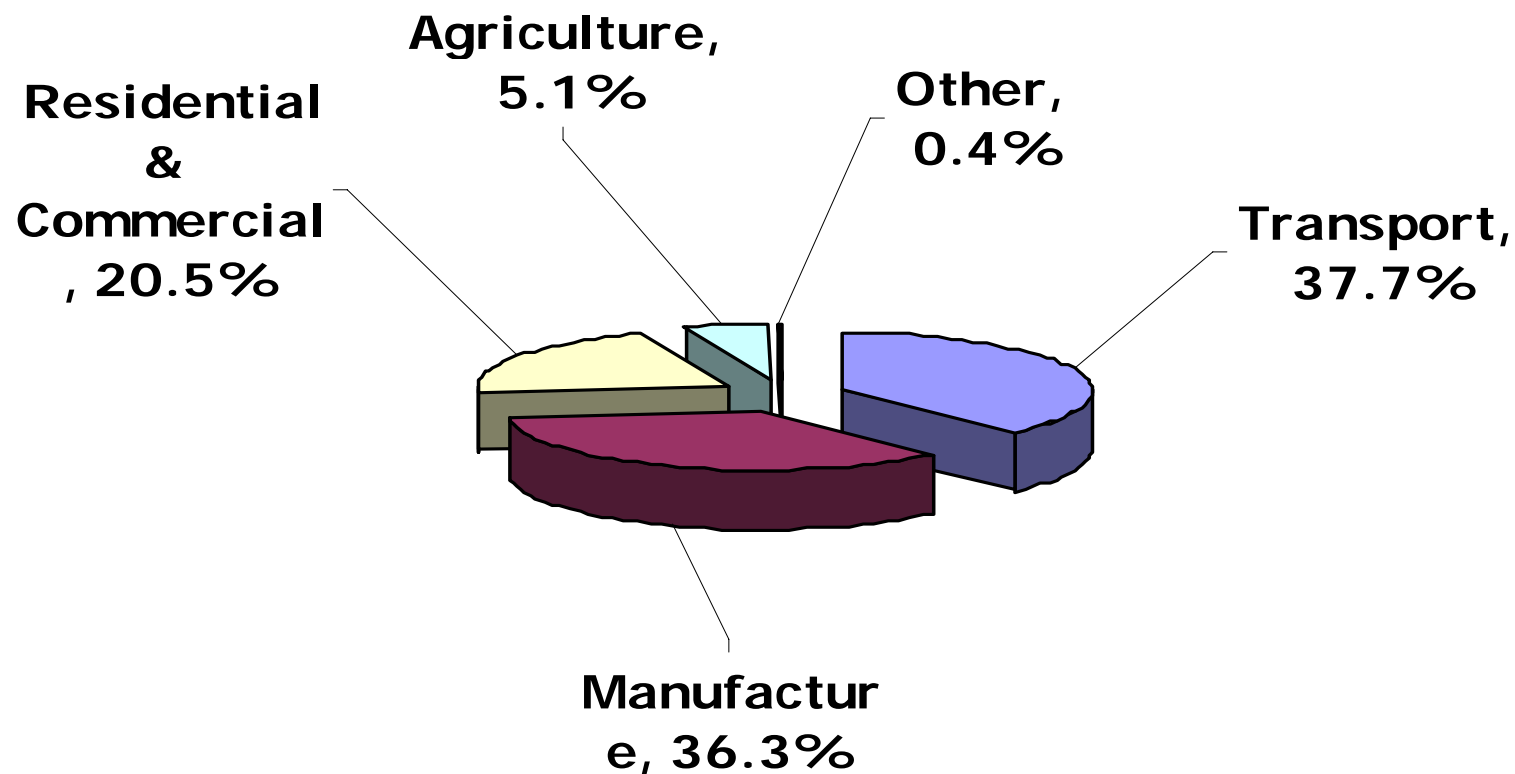
CE
83%



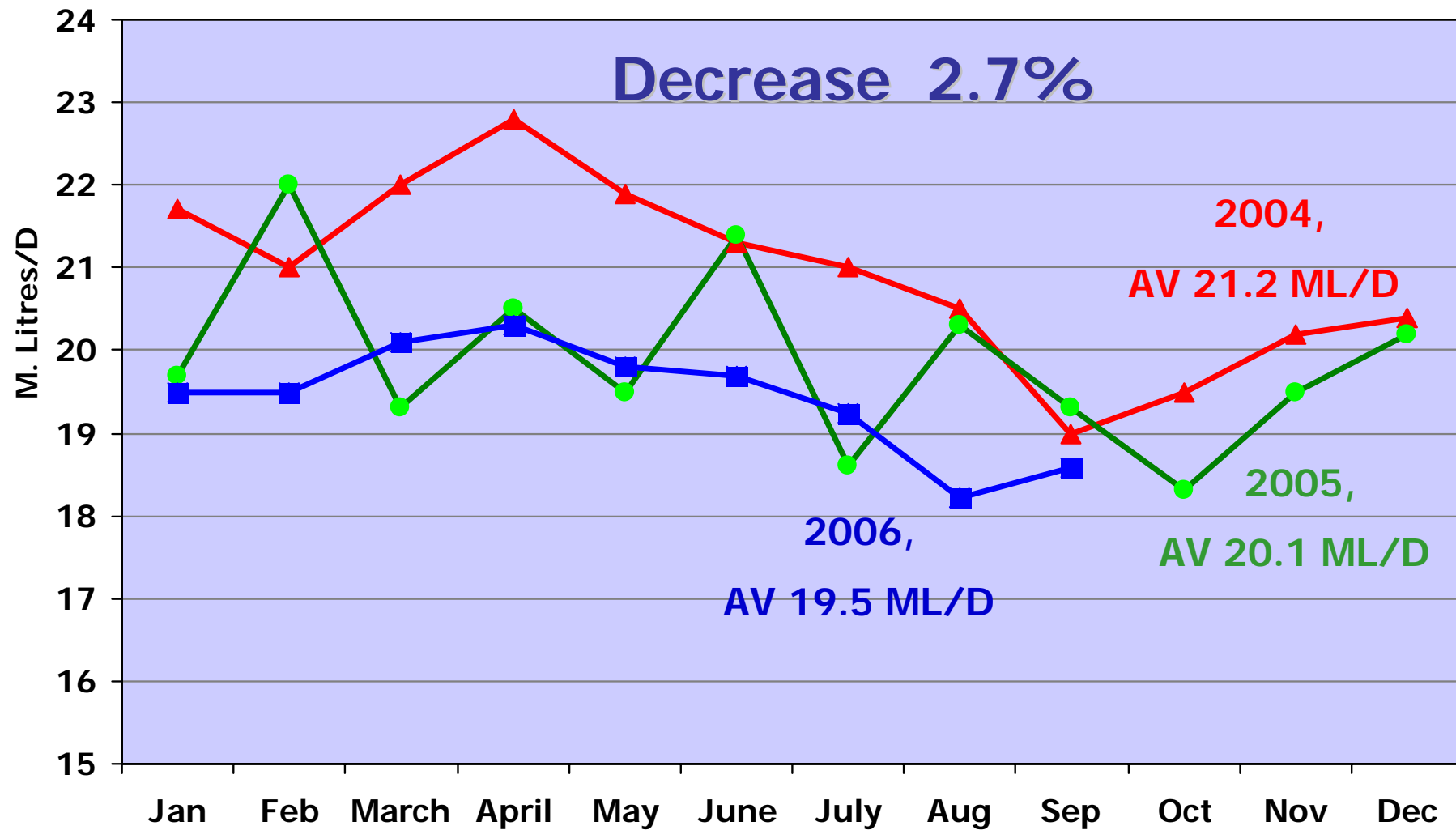
Final Energy Consumption by Economic Sectors (ktoe)

| Sectors | 2001 | 2002 | 2003 | 2004 | 2005 |
|--------------------------|---------------|---------------|---------------|---------------|---------------|
| Transportation | 18,632 | 19,636 | 20,927 | 22,812 | 23,491 |
| Manufacturing | 16,922 | 18,679 | 19,988 | 21,961 | 22,641 |
| Residential & Commercial | 10,920 | 11,377 | 11,799 | 12,667 | 12,779 |
| Agriculture | 2,847 | 3,032 | 3,308 | 3,520 | 3,207 |
| Mining & Construction | 221 | 255 | 267 | 302 | 277 |
| Total | 49,542 | 52,979 | 56,289 | 61,262 | 62,395 |

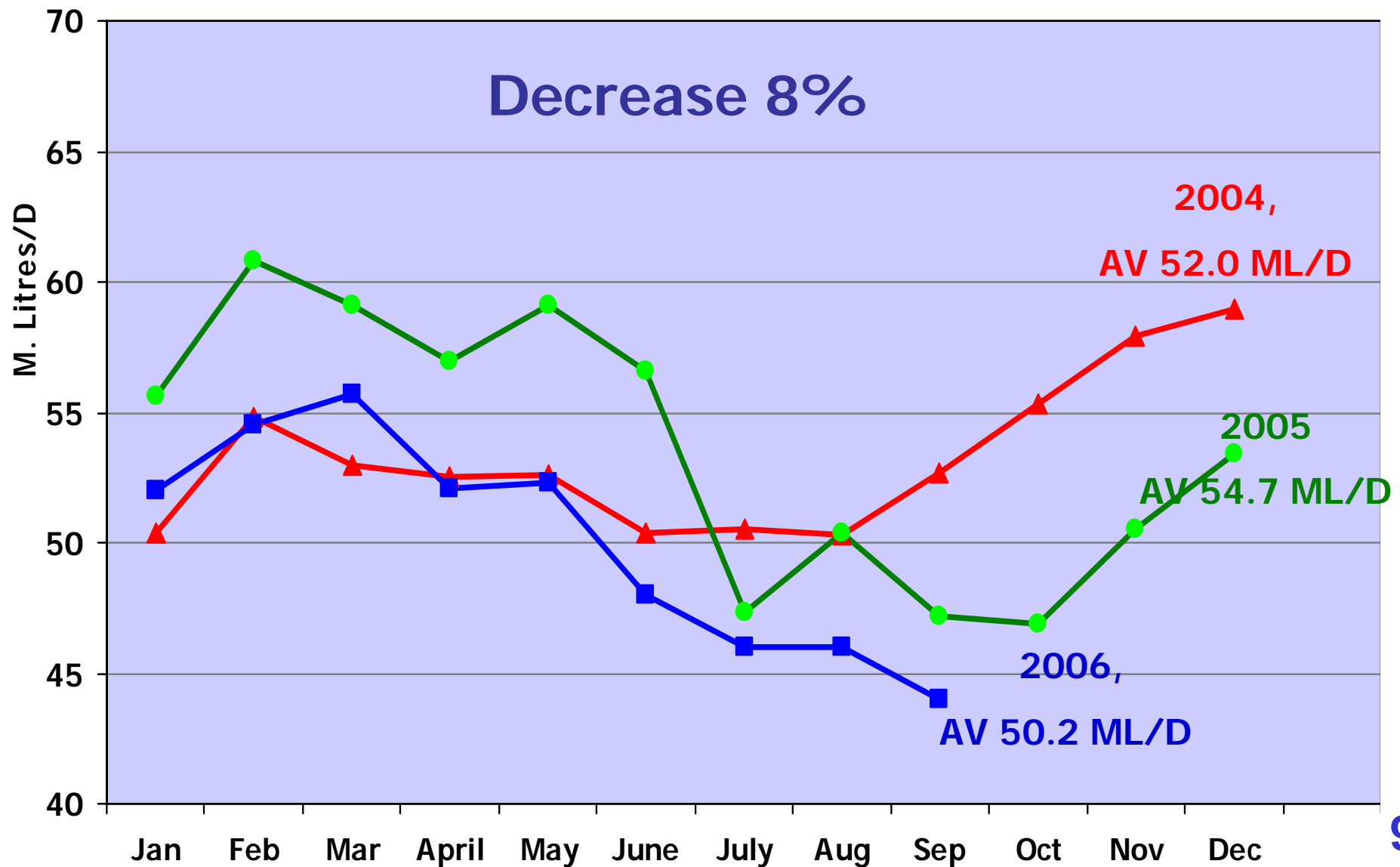
Energy Consumption by Economic Sectors in 2005



Gasoline Consumption, 2004-2006



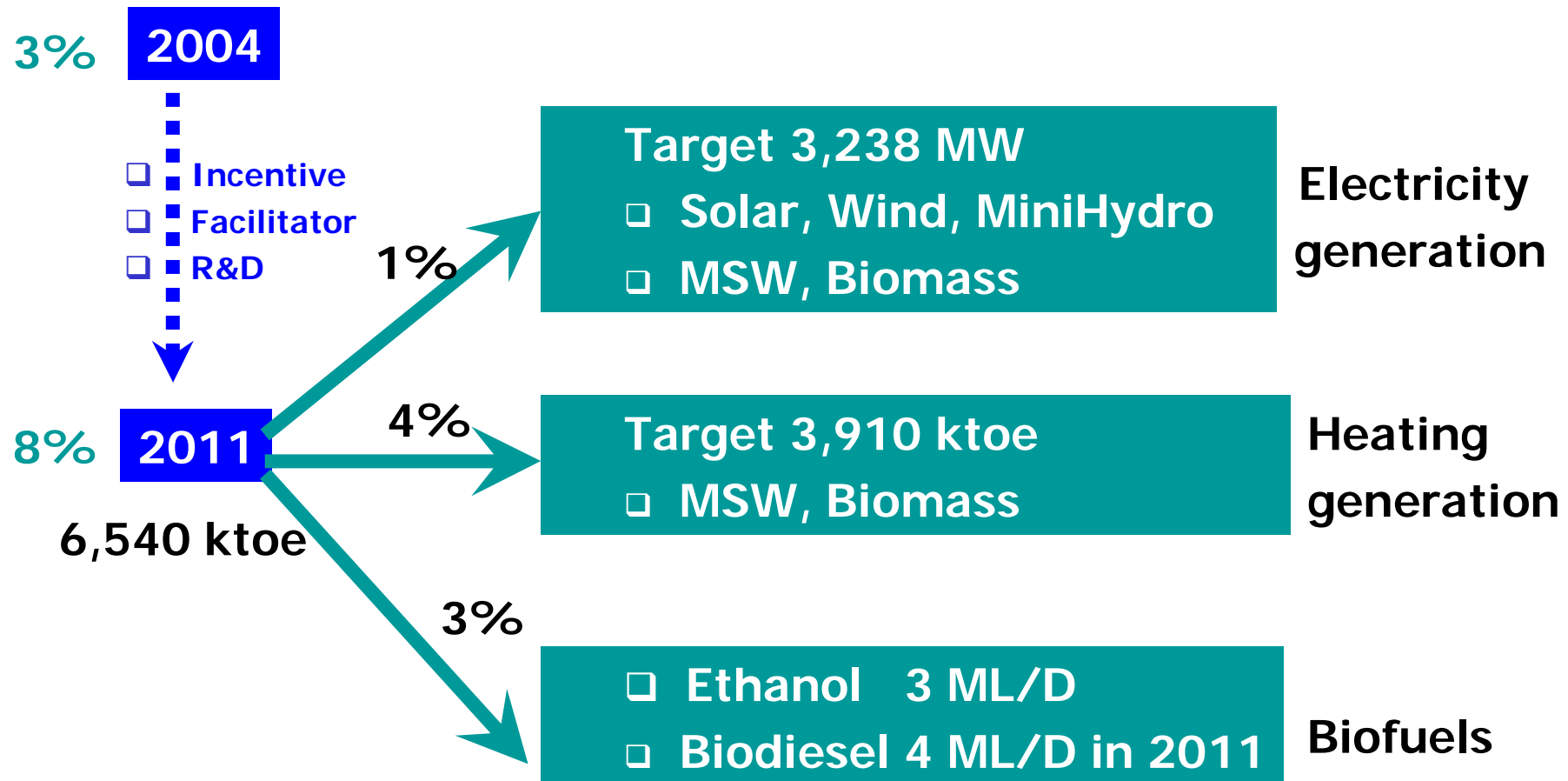
Diesel Oil Consumption, 2004-2006



Energy and Environment

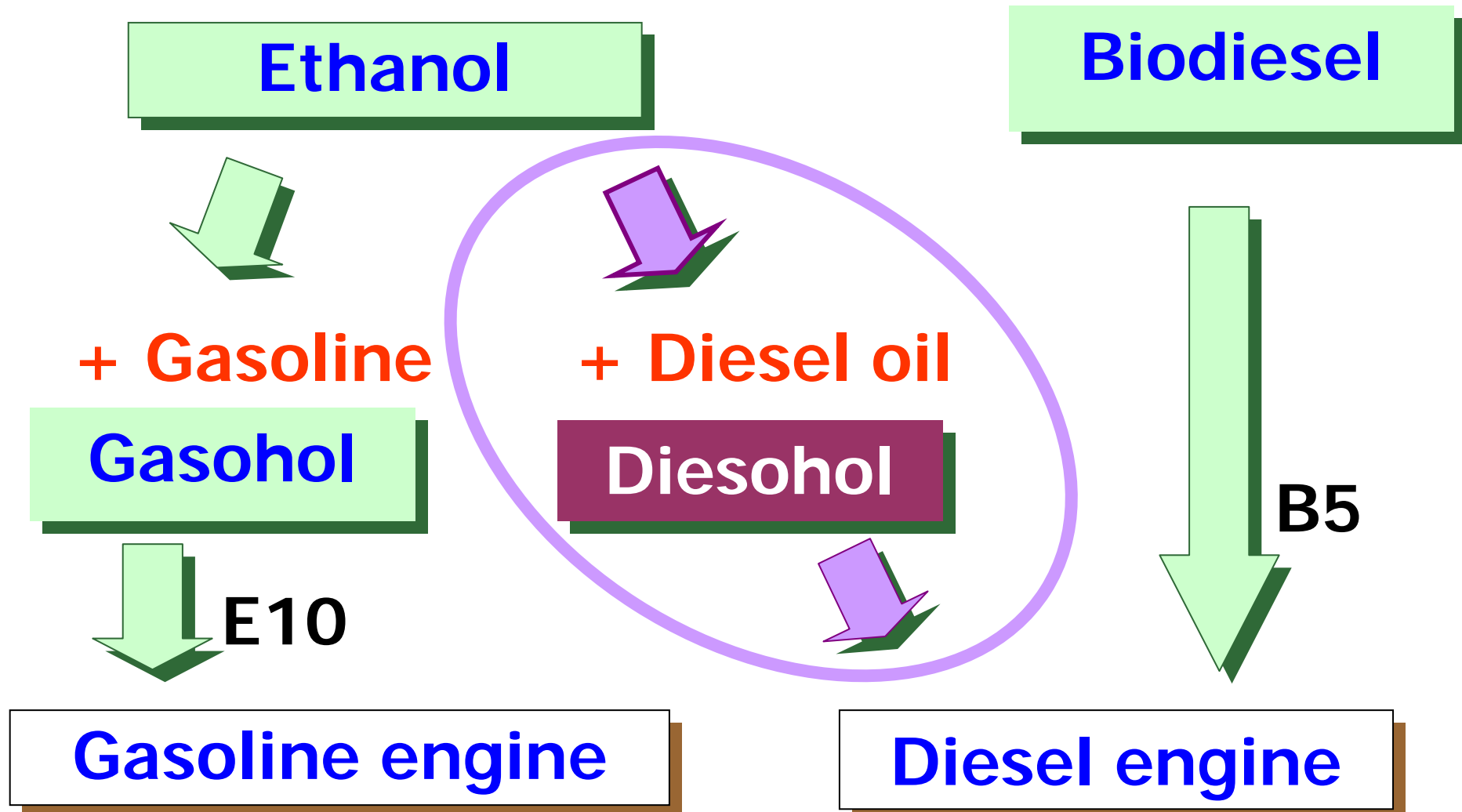
| | |
|-------------|--|
| 1996 | Launching unleaded gasoline |
| 1998 | Reduce sulfur content in diesel oil from 3% to 2% |
| 1999 | Reduce sulfur content in diesel oil from 0.5 % to 0.05 % |
| 2000 | Cabinet approved the establishment of ethanol plant for fuel |
| 2004 | Reduce sulfur content in diesel oil from 0.05 % to 0.035 % |
| 2005 | Declaration of biodiesel standard and start the sale of biodiesel |

Target of NRE in 2011*



* Cabinet Resolution on June 8, 2004, www.dede.go.th

Renewable Energy in Transport Sector



Strategic Plan for Ethanol Promotion

2005*

- ❑ Targeting the use of gasohol 4 ML/D by 2005 or Ethanol 0.4 ML/D in 2005
- ❑ Expansion the number of gasohol service station to 4,000 stations by 2005

2007

- ❑ Exemption the selling of 95-octane unleaded gasoline by 1 Jan 2007

2011

- ❑ Targeting Ethanol 3 ML/D in 2011

* Cabinet resolution on April 19, 2005

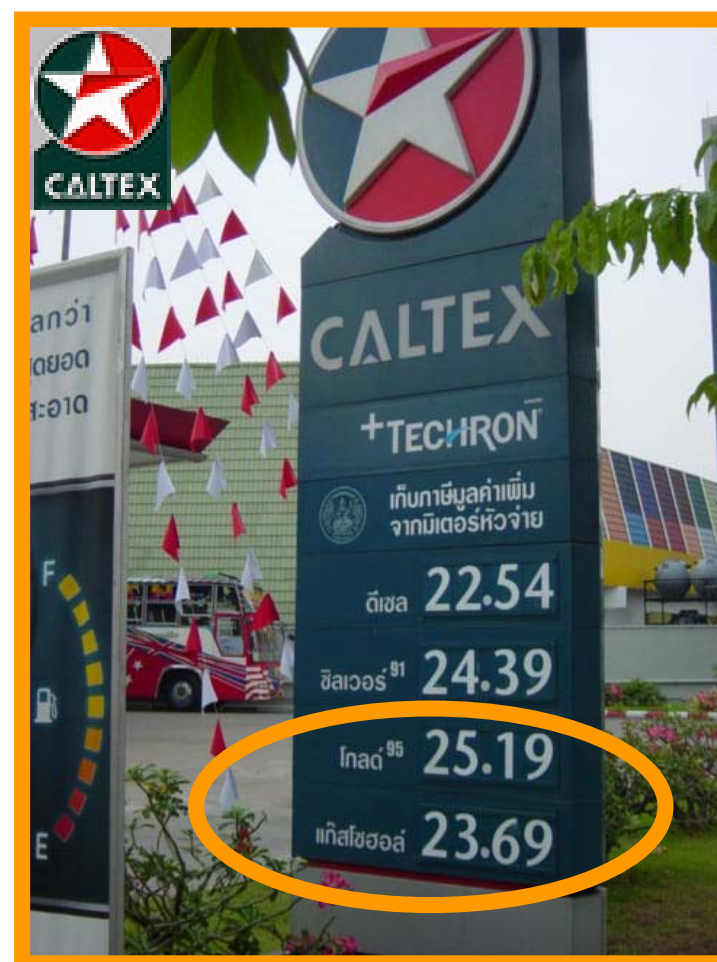
Fuel Ethanol Plants in Thailand

| Name of the company | Location | Raw Materials | Capacity (L/D) |
|---|---------------|-----------------|----------------|
| On-going Production | | | 855,000 |
| Porn Wilai Co., Ltd. | Ayuthaya | Molasses | 25,000 |
| Thai Alcohol Co., Ltd. | Nakhon Pratum | Molasses | 200,000 |
| Thail Agro Energy Co., Ltd. | Suphan Buri | Molasses | 150,000 |
| Thai Nguan Ethanol Co., Ltd. | Khon Khaen | Cassava | 130,000 |
| Khon Khaen Alcohol Co., Ltd. | Khon Khaen | Sugar, Molasses | 150,000 |
| Petro Green Co., Ltd. | Chaiyaphum | Sugar, Molasses | 200,000 |
| Starting Production by the first quarter of 2007 | | | 260,000 |
| Thai Sugar Ethanol | Kanchana Buri | Molasses | 100,000 |
| Fa Kuan Tip Co. Ltd. | Prachinburi | Cassava | 60,000 |
| Ekarat Patana | Nakhon Sawan | Molasses | 100,000 |

as of January 2007



THAILAND: Gasoline Service Station



Number of Gasohol Service Stations (E10)

| | |
|-------------|-------|
| BKK | 694 |
| Outside BKK | 2,751 |
| Total | 3,445 |

as of November 2006

| | |
|----------------------|-------|
| 1. PTT | 1209 |
| 2. Bangchak | 693 |
| 3. Shell | 548 |
| 4. TPI | 38 |
| 5. ESSO | 489 |
| 6. Chevron | 293 |
| 7. Conoco | 88 |
| 8. Petronas | 55 |
| 9. Siam Saha Service | 20 |
| 10. Southern Fuel | 12 |
| total | 3,445 |

Gasohol Selling Volume (E10)

| Years | Gasohol selling | | Target |
|-------|-----------------|--------|--------|
| | Million Litres | ML/Day | ML/Day |
| 2001 | 1.6 | 0.004 | - |
| 2002 | 0.5 | 0.001 | - |
| 2003 | 2.6 | 0.007 | - |
| 2004 | 59.6 | 0.163 | - |
| 2004 | 674.9 | 1.85 | 4.0 |
| 2005 | 1,056.9 | 3.5 | 4.0 |

as of November 2006

Standard Specification of Gasohol

| Fuel properties | Limit | Specification of gasohol | |
|-----------------------------------|-------|--------------------------|-----------|
| | | Octane 91 | Octane 95 |
| 1. Octane number | | | |
| 1.1 Research Octane Number, RON | | | |
| Distributor, at delivery location | min | 91.0 | 95.0 |
| Dealer | min | 90.6 | 94.6 |
| 1.2 Motor Octane Number, MON | | | |
| Distributor, at delivery location | min | 80.0 | 84.0 |
| Dealer | min | 79.6 | 83.6 |
| 2. Lead Content, g/L | max | 0.013 | 0.013 |
| 3. Sulfur Content, g/L | max | 0.05 | 0.05 |
| 4. Phosphorus Content, g/L | max | 0.0013 | 0.0013 |
| 5. Corrosion | max | No. 1 | No. 1 |
| 6. Oxidation Stability, minutes | min | 360 | 360 |
| 7. Solvent Washed Gum, mg/100 mL | max | 4 | 4 |

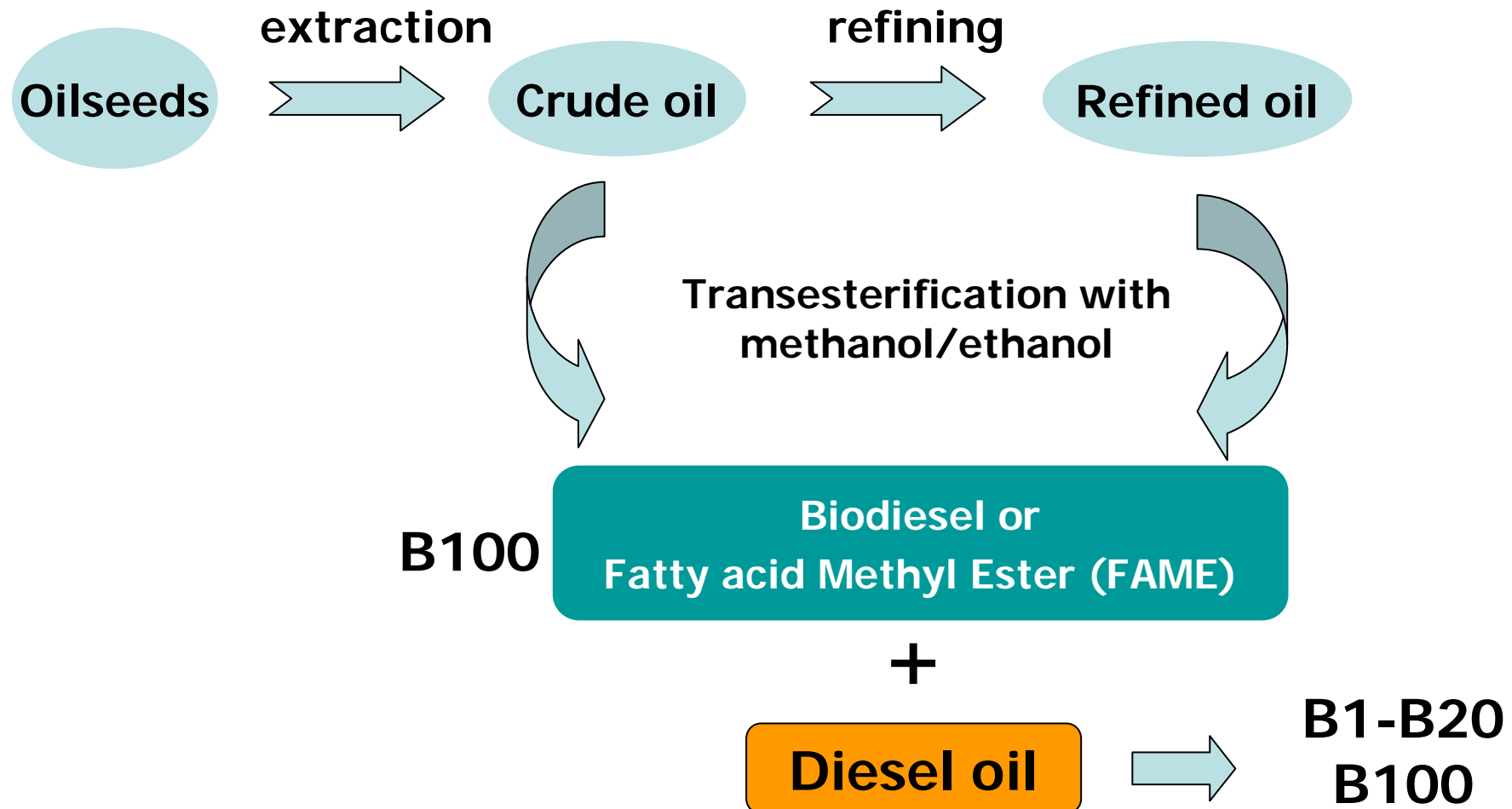
Standard Specification of Gasohol (Cont.)

| Fuel properties | | | Limit | Octane 91 | Octane 95 |
|-----------------|------------------------------|------------------------|------------|-----------|-----------|
| 8. | Distillation | | | | |
| 8.1 | Temperature, °C | 10% Evaporated | max | 70 | 70 |
| | | 50% Evaporated | min | 70 | 70 |
| | | | max | 110 | 110 |
| | | 90% Evaporated | max | 170 | 170 |
| | | End Point | max | 200 | 200 |
| | 8.2 | Residue, %vol. | max | 2.0 | 2.0 |
| 9. | Vapour Pressure @37.8°C, kPa | | max | 62 | 62 |
| 10. | Benzene Content, %vol. | | max | 3.5 | 3.5 |
| 11. | Aromatic Content, %vol. | | max | 35 | 42 |
| | <i>From January 1, 2008</i> | | <i>max</i> | <i>35</i> | <i>35</i> |
| 12. | Color | 12.1 Hue | | green | orange |
| | | 12.2 Dye Content, mg/L | min | 4.0 | 10.0 |
| 13. | Water Content, %wt. | | max | 0.7 | 0.7 |
| 14. | Denatured Ethanol, %vol. | | min | 9 | 9 |
| | | | max | 10 | 10 |

The National Strategic Plan for Development and Promotion on the Use of Biodiesel

- 1. Community-based biodiesel production:**
to be used for agricultural machines in
the communities
- 2. Commercial-based biodiesel
production:**
the target of 8.5 ML per day by 2012*

Biodiesel for diesel engine



Potential feedstocks for biodiesel production in Thailand

Jatropha oil



Waste
cooking
oil



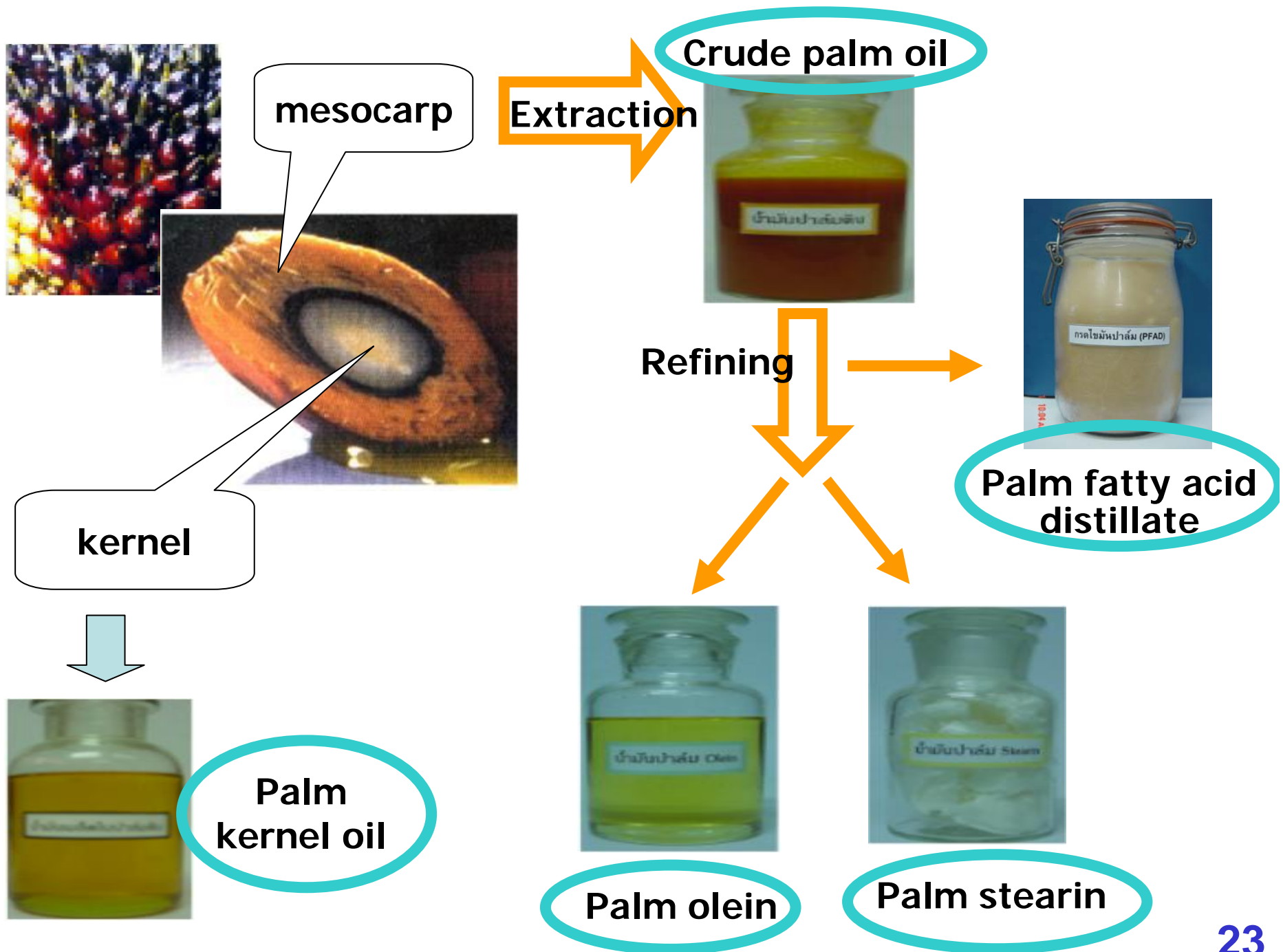
Coconut oil



Sunflower
oil



Palm
oil



Biodiesel from various oils



Standard Specifications of Biodiesel for Agricultural Engines

| Item | Fuel properties, | Unit | Standard limit | |
|------|------------------------|-------------------|------------------------|--------|
| 1. | Density at 15° C | kg/m ³ | min | 860 |
| | | | max | 900 |
| 2. | Viscosity at 40°C | CSt | min | 1.9 |
| | | | max | 8.0 |
| 3. | Flash Point | °C | min | 120 |
| 4. | Sulphur | % wt. | max | 0.0015 |
| 5. | Cetane Number | | min | 47 |
| 6. | Sulfated Ash | % wt. | max | 0.02 |
| 7. | Water and sediment | % vol. | max | 0.2 |
| 8. | Copper Strip Corrosion | | max | No. 3 |
| 9. | Acid Number | mg KOH/g | max | 0.80 |
| 10. | Free glycerin | % wt. | max | 0.02 |
| 11. | Total glycerin | % wt. | max | 1.5 |
| 12. | Colour | | | Purple |
| 13. | Additive | | Approved by DG of DOEB | |

Standard Specifications of Biodiesel - FAME

| Item | Fuel properties | Unit | Standard limit | |
|------|--|-------------------|----------------|--------|
| 1. | Methyl Ester | % wt. | min | 96.5 |
| 2. | Density at 15° C | kg/m ³ | min | 860 |
| | | | max | 900 |
| 3. | Viscosity at 40°C | CSt | min | 3.5 |
| | | | max | 5.0 |
| 4. | Flash Point | °C | min | 120 |
| 5. | Sulphur | % wt. | max | 0.0010 |
| 6. | Carbon Residue, on 10% distillation residue | % wt. | max | 0.30 |
| 7. | Cetane Number | | min | 51 |
| 8. | Sulfated Ash | % wt. | max | 0.02 |
| 9. | Water | % wt. | max | 0.050 |
| 10. | Total Contaminate | % wt. | max | 0.0024 |
| 11. | Copper Strip Corrosion | | max | No. 1 |
| 12. | Oxidation Stability at 110°C | hours | min | 6 |

Standard Specifications of Biodiesel - FAME

Cont.

| Item | Fuel properties | Unit | Standard limit | |
|------|-----------------------------|----------------|------------------------|-------------|
| 13. | Acid Value | mg KOH/g | max | 0.50 |
| 14. | Iodine Value | g Iodine/100 g | max | 120 |
| 15. | Linolenic Acid Methyl Ester | % wt. | max | 12.0 |
| 16. | Methanol | % wt. | max | 0.20 |
| 17. | Monoglyceride | % wt. | max | 0.80 |
| 18. | Diglyceride | % wt. | max | 0.20 |
| 19. | Triglyceride | % wt. | max | 0.20 |
| 20. | Free glycerin | % wt. | max | 0.02 |
| 21. | Total glycerin | % wt. | max | 0.25 |
| 22. | Group I metals (Na+K) | mg/kg | max | 5.0 |
| | Group II metals (Ca+Mg) | mg/kg | max | 5.0 |
| 23. | Phosphorus | % wt. | max | 0.0010 |
| 24. | Additive | | Approved by DG of DOEB | |

THAILAND: Biodiesel Service Station



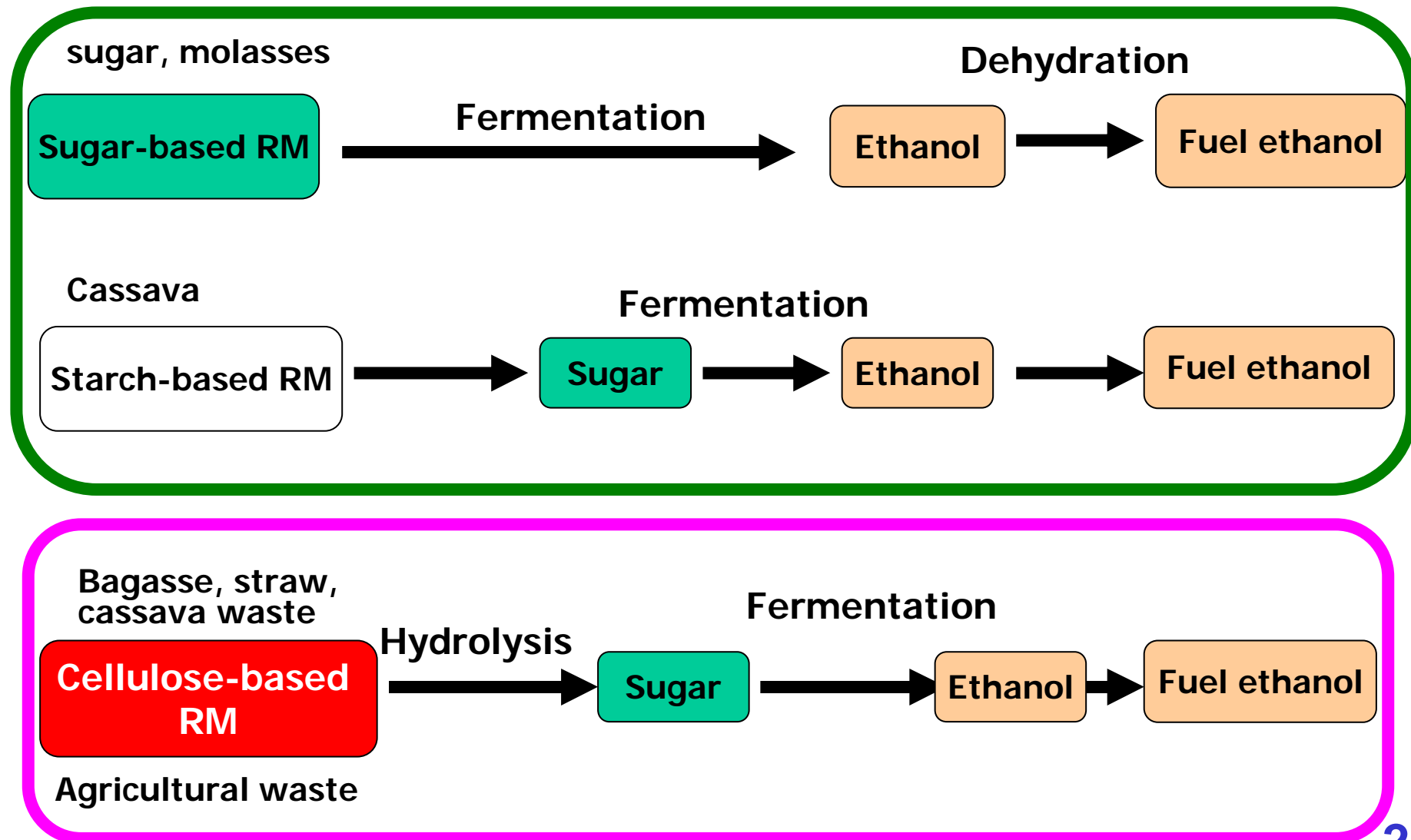
30 stations



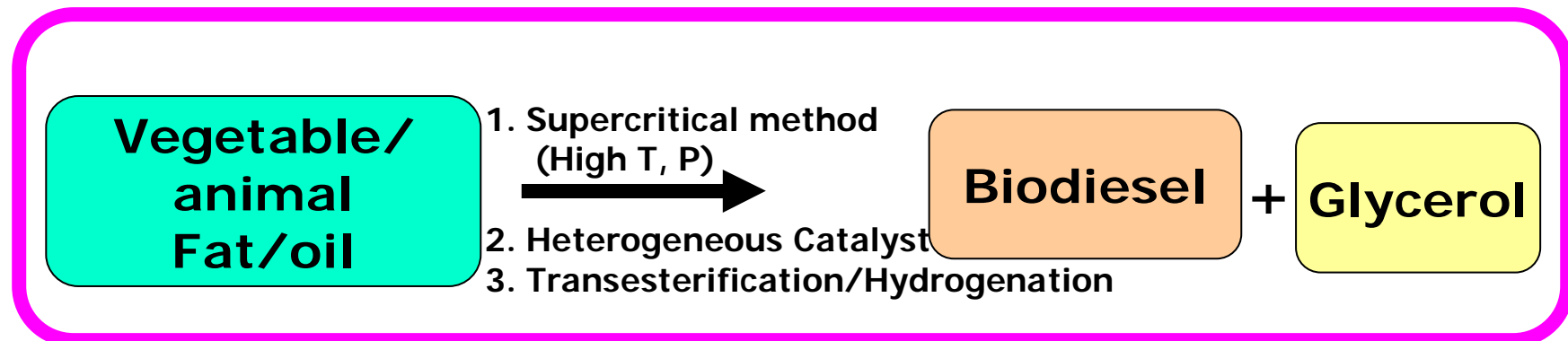
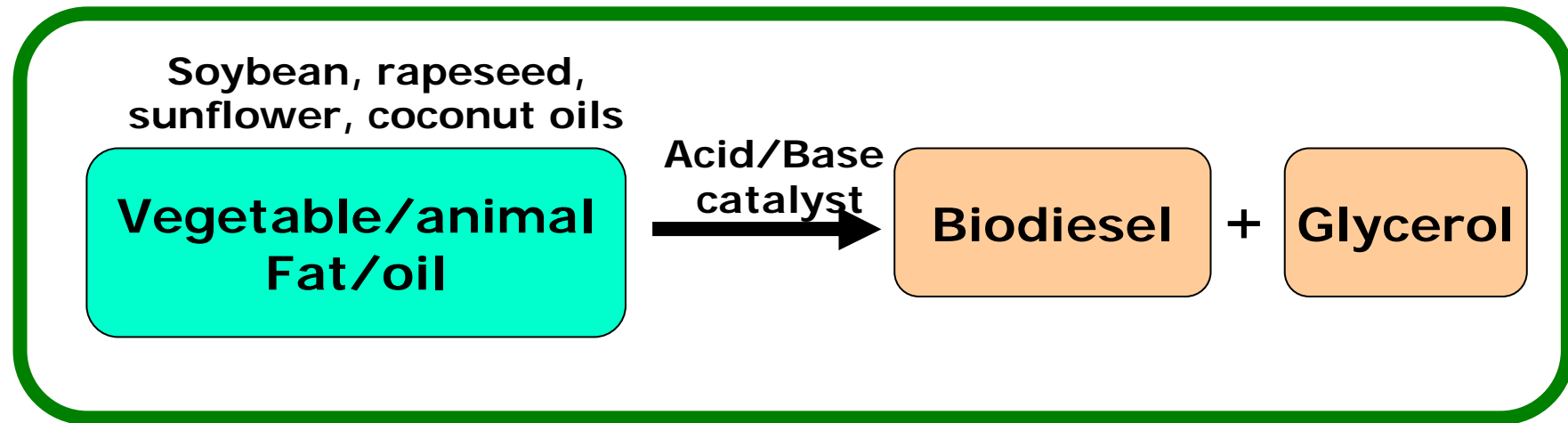
145 stations

Biodiesel B5 selling:
3.4 ML in October 2006

Ethanol Production



Biodiesel Production



Fatty acid composition of BDF from various feedstocks in Thailand

| Fatty acid | BDF from | | | | | | |
|------------------------------|----------------|-------------------|--------------|--------------|--------------|-------------|---------------|
| | Crude palm oil | Crude coconut oil | Jatropha oil | Palm stearin | Palm olein | Soybean oil | Sunflower oil |
| Caproic acid, C8:0 | - | 7.42 | - | - | - | - | - |
| Capric acid, C10:0 | - | 5.78 | - | - | - | - | - |
| Lauric acid, C12:0 | 0.35 | 49.75 | - | 0.25 | 0.37 | 0.1 | - |
| Myristic acid, C14:0 | 0.92 | 18.75 | - | 1.27 | 0.91 | 0.2 | 0.1 |
| Palmitic acid, C16:0 | 44.11 | 8.60 | 14.85 | 59.19 | 38.53 | 10.7 | 6.0 |
| Stearic acid, C18:0 | 4.36 | 2.65 | 7.43 | 4.43 | 0.08 | 3.9 | 4.0 |
| Arachidic acid, C20:0 | 0.09 | 0.18 | 0.08 | 0.31 | 0.13 | Other = 0.2 | Other = 1.1 |
| Sum of Saturated FA | 49.83 | 93.13 | 22.36 | 65.45 | 40.02 | 15.1 | 11.2 |
| Palmitoleic acid, C16:1 | - | - | - | 0.08 | - | 0.3 | <1.0 |
| Oleic acid, C18:1 | 38.97 | 5.53 | 47.65 | 28.61 | 58.13 | 22.8 | 16.5 |
| Linoleic acid, C18:2 | 11.21 | 1.26 | 29.80 | 5.86 | 1.78 | 50.8 | 72.4 |
| Linolenic acid, C18:3 | - | 0.07 | 0.19 | - | 0.07 | Other = 6.8 | Other = 0.6 |
| Sum of Unsaturated FA | 50.18 | 6.86 | 77.64 | 34.55 | 59.98 | 80.7 | 90.5 |

Joint Research Between
the **Thailand Institute of Scientific and Technological Research (TISTR)**, Thailand,
MTEC, Thailand
and the **Energy Technology Research Institute (ETRI) of AIST**, Japan



**Biodiesel Fuel and Clean Engine:
Standardization and Upgrading of BDF Quality**



Joint study on:

- ❑ Development of standards for biodiesel fuel quality and standards for ensuring BDF quality
- ❑ Development of BDF upgrading including the novel BDF production technologies

JOINT RESEARCH: Biodiesel Fuel and Clean Engine: Standardization and Upgrading of BDF Quality

Study on fuel properties during storage:

oxidation stability, acid value, viscosity



Development of biodiesel upgrading technologies

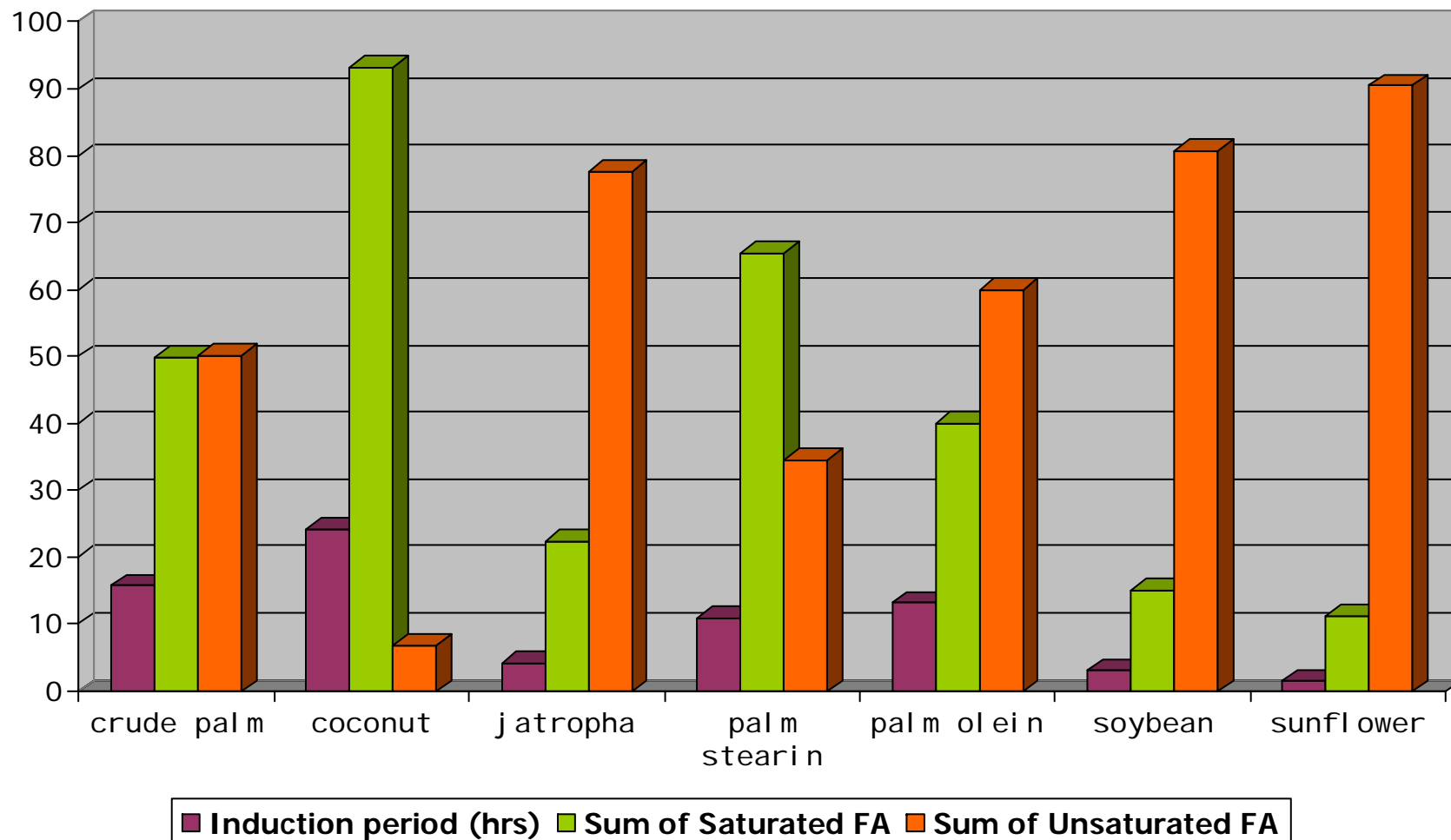
- ☐ Hydrogenation
- ☐ Heterogeneous Catalyst



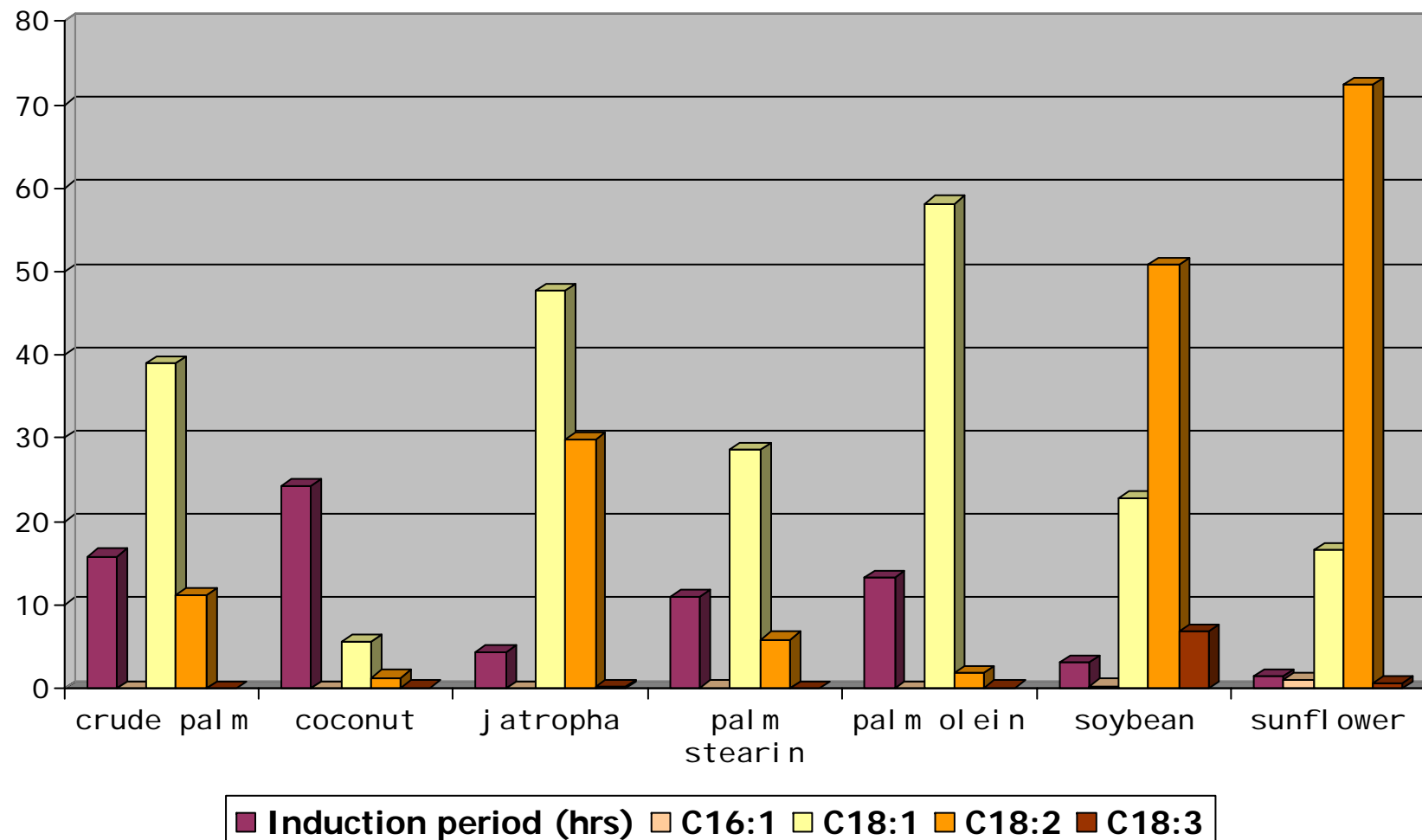
Oxidation Stability of BDF from various oils

| Biodiesel | Induction Period at 110°C (hrs) |
|-------------------|------------------------------------|
| Crude palm oil | 15.78 |
| Crude coconut oil | 24.19 |
| Jatropha oil | 4.26 |
| Palm stearin | 10.98 |
| Palm olein | 13.19 |
| Soybean oil | 3.11 |
| Sunflower oil | 1.43 |

Induction period VS amount of saturated FA



Induction period VS amount of unsaturated FA



Demonstration: Bus at AIST using BDF Fuel



Conclusion

- ☐ Strong government incentives and supports
- ☐ Extending and enhancing plantation productivity for ethanol and biodiesel feedstocks
- ☐ Add value to the byproducts of biofuel productions
- ☐ Investigate and promote new feedstocks; i,e.
 - ☐ Cellulosic feedstock, for ethanol
 - ☐ Sweet sorghum, for ethanol
 - ☐ Jatropha nut, for biodiesel