Session 2A: Dr. Nuwong Chollacoop

Presentation entitled:
A Study on Energy and Co2 Intensities of Freight Transport by Trucks

Biographic Data of Speaker

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EXPERIENCES

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Date	Jun – Aug 2010
Institution	Institute for Combustion Engines (VKA), RWTH-Aachen University, Germany
Subject	**Invited Researcher**, DAAD Research Short Stay 2010 Conduct research collaboration under Cluster of Excellence, "Tailor-Made Fuels from Biomass (TMFB)" in the field of "Combustion engine and Optical diagnostics" under funding by Deutscher Akademischer Austausch Dienst (**DAAD**)

Date	Dec 2009
Institution	National Institute of Advanced Industrial Science and Technology (**AIST**), JAPAN

Date	Nov 2008 – present
Institution	Economic Research Institute for ASEAN and East Asia (**ERIA**)
Subject	**Country Expert** for the Working Group on • Benchmarking of Biodiesel Fuel Standardization in East Asia, operated by **NFV**, **AIST** • Sustainable Automobile Society in East Asia, operated by **JARI** (Japan Automotive Research Institute)

Date	Jan 2007
Institution	National Institute of Advanced Industrial Science and Technology (**AIST**), JAPAN
Subject	**Visiting Researcher**, Energy Technology Research Institute (ETRI) Conduct research collaboration in the field of "Standardization and Upgrading of Biodiesel Fuel Quality" under funding by **NEDO** (New Energy and Industrial Technology Development Organization) of Japan during 2005-2007

SELECTED PUBLISHED WORKS

- **N. Chollacoop**, P. Saisirirat, T. Fukuda and A. Fukuda, "Scenario Analyses of Road Transport Energy Demand: A Case Study of Ethanol as a Diesel Substitute in Thailand," Energies, 4 (2011), 108-125
- S. Sukkasi, **N. Chollacoop**, W. Ellis, S. Grimley and S. Jai-In, "Challenges and considerations for planning toward sustainable biodiesel development in developing countries: Lessons from the Greater Mekong Subregion," Renewable and Sustainable Energy Reviews, 14 (2010), 3100-3107
- N. Viriya-empikul, P. Krasae, B. Puttasawat, B. Yoosuk, **N. Chollacoop** and K. Faungnawakij, "Waste shells of mollusk and egg as biodiesel production catalysts," Bioresource Technology, 101 (2010), 3765-3767
- S. Topaiboul and **N. Chollacoop** , "Biodiesel as a lubricity additive for ultra low sulfur diesel," Songklanakarin Journal of Science and Technology, 32 (2010), 153-156

A CASE STUDY ON ENERGY AND CO_2 INTENSITIES IN THAI FREIGHT TRANSPORT BY TRUCKS

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Thailand is heavily dependent on oil-import, accounting for more than 80% of country's demand. Transportation is a dominant end-use sector of the oil supply, where more than 70% of total petroleum products are consumed by this sector. Furthermore, it correspondingly contributes about 25% of energy-related carbon dioxide (CO_2) emissions. However, transportation is recognized as a main driving force for the country's economic development, particularly the freight transport, which supplies trade activities. Since the logistic cost of Thailand is relatively high comparing with other countries, e.g. Japan, Korea, Taiwan, the government has recently projected a clear target to reduce logistic cost to be 15% of GDP by next 5 years. Transportation shares even half of the country's logistic cost.

More specifically, energy efficiency improvement and CO_2 reduction in Thai freight transport sector is of crucial importance, and need a well-planned policy to achieve the target. However, to the best of authors' knowledge in energy conservation and GHG (Greenhouse Gas) mitigation in transport sector for Thailand, there is no available data of energy and environment efficiency indicators for freight transport, particularly for truck transport, which is a major mode of freight movement. Energy consumed for a unit of transportation activity or so-called energy intensity is useful for planning and implementing policies. For the environment aspect, CO_2 intensity, or CO_2 emitted for a unit of transport activity, can also be calculated from the GHG guideline proposed by IPCC[1] on fuel used in the energy intensity calculation.

This study aims to develop energy and CO_2 intensities of truck transport in Thailand by recourse to a case study. The proposed study would deliver essential and informative results for further studies on transportation efficiency improvement in Thailand.

[1] Intergovernmental Panel on Climate Change—IPCC (2006), http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.htm

A Case Study on Energy and CO_2 Intensities in Thai Freight Transport by Trucks

กรณีศึกษาด้านความเข้มข้นของการใช้พลังงานและการปลดปล่อยก๊าซคาร์บอนไดออกไซด์ของการขนส่งสินค้าด้วยรถบรรทุก

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ATRANS Research Final Presentation
19 August 2011, 11:40 – 12:00
ATRANS Office, Bangkok/THAILAND

A Driving Force for National Science and Technology Capability

Presentation outline

- Rationale
  - Current situation (esp. transportation sector) & prediction
    - ✓ Energy consumption vs. GHG emission
  - National Energy Efficiency Plan (2011-2030)
  - IEA figure for energy intensity
- Objective: get estimate of energy/CO_2 intensities in Thai freight transport
- Methodology & scope
  - Schipper's approach
  - Scope of interest
    - ✓ Macro level: country ton-km & fuel consumption in freight sector
    - ✓ Micro level: company specific
- Results & Discussion
  - Macro level analysis
    - ✓ Use energy demand modeling to estimate fuel consumption in freight
    - ✓ Use ton-km of commodities from Transport portal (Ministry of Transport)
  - Micro level analysis: LTM (Logistic Transport Management) project data
- Questions/Comments?

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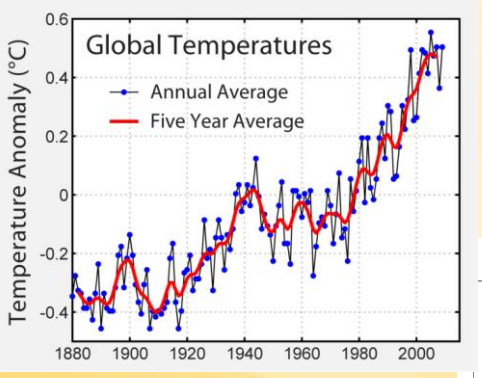
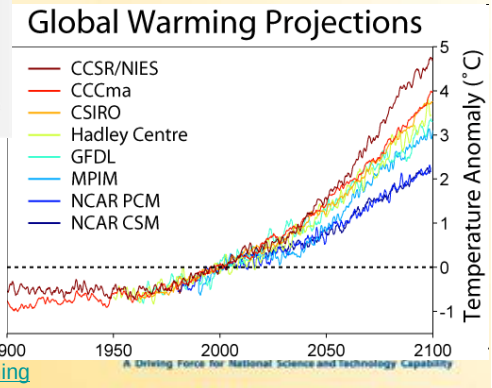
Rationale



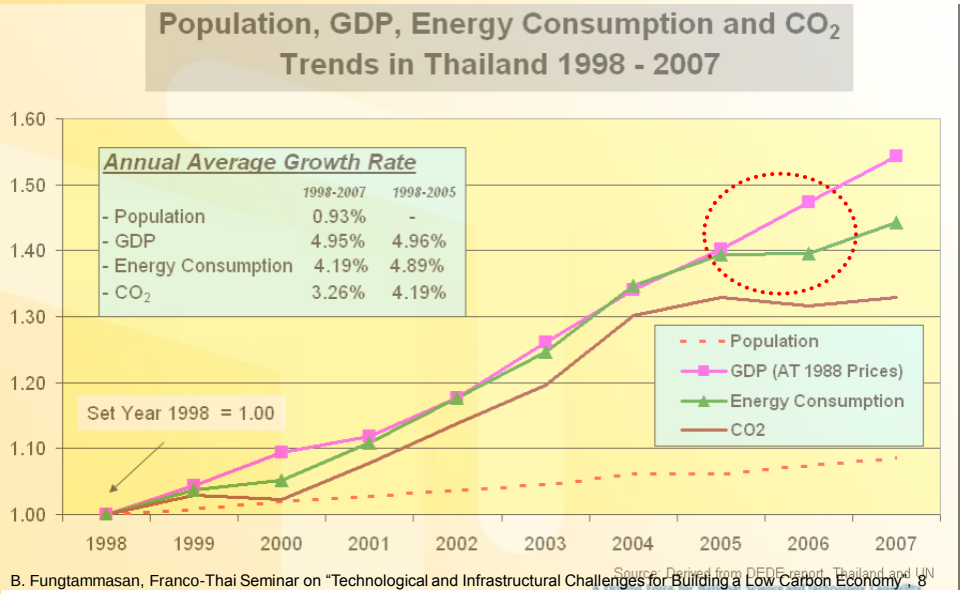
- Alarming Global Warming
- Historical data record projects temperature anomaly in the future



- Countless effects
  - Physical: climate change, iceberg melting, ocean anomaly
  - Social: food shortage, emerging disease, relocation

Source: http://en.wikipedia.org/wiki/Global_warming

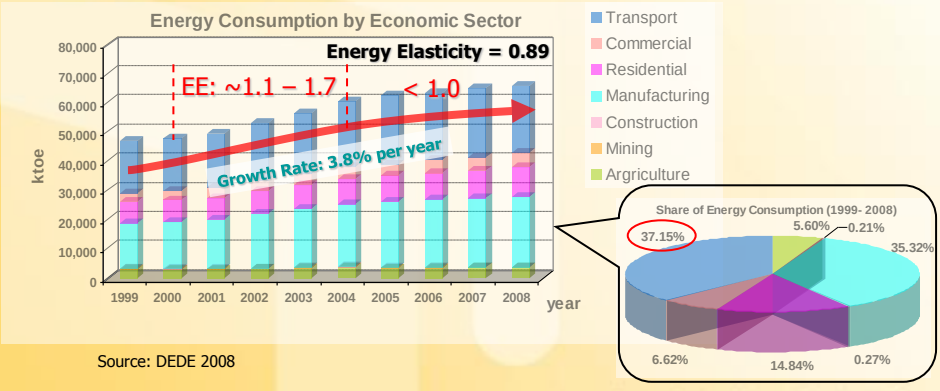
Energy Consumption vs. CO_2 emission in Thailand



B. Fungtammasan, Franco-Thai Seminar on "Technological and Infrastructural Challenges for Building a Low Carbon Economy", 8 Oct 2009, Bangkok

Energy Consumption in Thailand

- Post economic crisis in 1997 (Tom Yam Kung crisis)
- Energy elasticity (EE) = % change in energy consumption to achieve one 1% change in national GDP*
- Transportation and Manufacturing → largest consumption

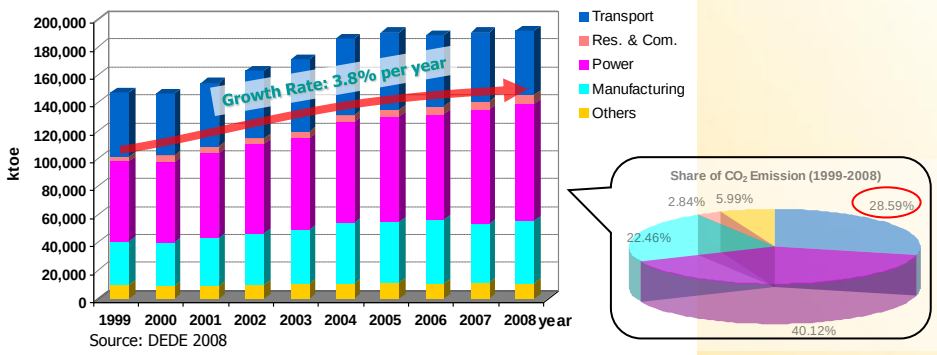


Source: DEDE 2008

* http://en.wikipedia.org/wiki/Energy_elasticity

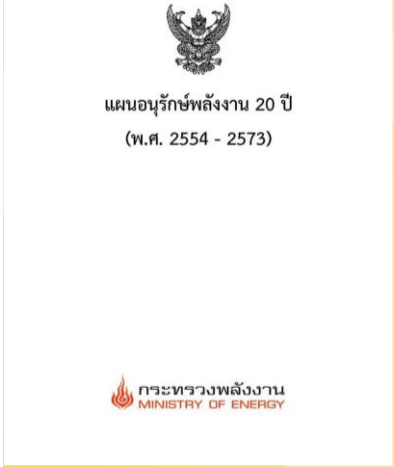
CO_2 Emission from Energy Sector in Thailand

- Calculated from energy used → similar growth
- Largest → power sector, followed by Transportation & Manufacturing



Source: DEDE 2008

National Energy Efficiency Plan (2011-2030)

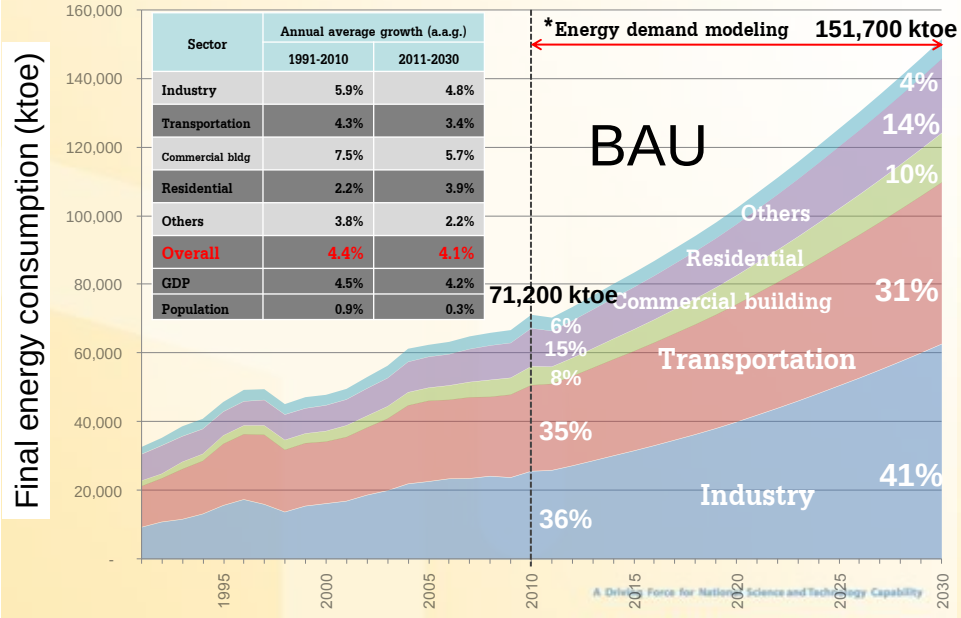


- Highlights
  - Reduce energy intensity by 25% in 2030 (base year 2005)
  - Reduce final energy consumption by 20% in 2030 (~30,000 ktoe)
  - Highest potential for EE plan
    - ✓ Transportation (13,300 ktoe)
    - ✓ Industry (11,300 ktoe)
  - Reduce energy elasticity from 0.98 to 0.7 within 20 years
  - Net results
    - ✓ Total energy conservation of 14,500 ktoe/year (272 billion THB/year)
    - ✓ Total CO2 reduction of 48 mtpa
  - Both mandatory and volunteer measures
    - ✓ Standard offer program (SOP)
    - ✓ Energy Efficiency Resource Standard (EERS)

http://www.eppo.go.th/encon/ee-20yrs/ee-20yr-final.pdf

National Energy Efficiency Plan (2011-2030)

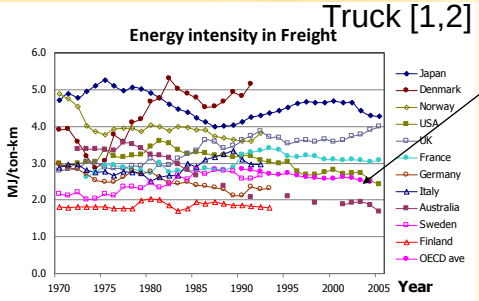
Sector	Annual average growth (a.a.g.)	
	1991-2010	2011-2030
Industry	5.9%	4.8%
Transportation	4.3%	3.4%
Commercial bldg	7.5%	5.7%
Residential	2.2%	3.9%
Others	3.8%	2.2%
Overall	4.4%	4.1%
GDP	4.5%	4.2%
Population	0.9%	0.3%



Energy Intensities of Freight Transport

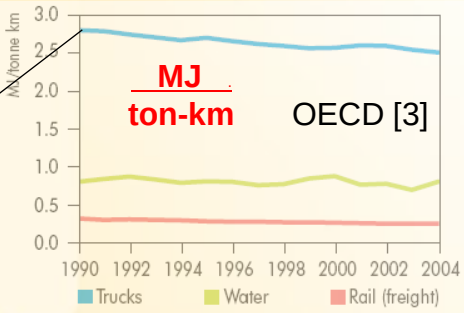
- Definition
  - Energy intensity = Energy consumed for a unit of transportation activity
  - CO_2 intensity = CO_2 emitted for a unit of transportation activity
- Example of such historic data of energy intensities in freight transport
- Clearly show characteristic and trend of each country
- Need good and consistent data recording!

Truck [1,2]



MJ / ton-km

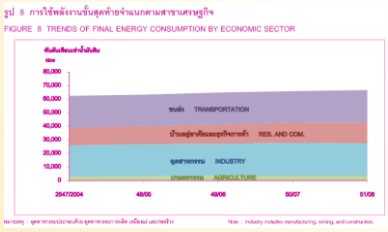
OECD [3]

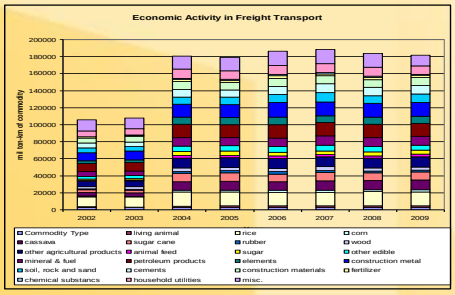


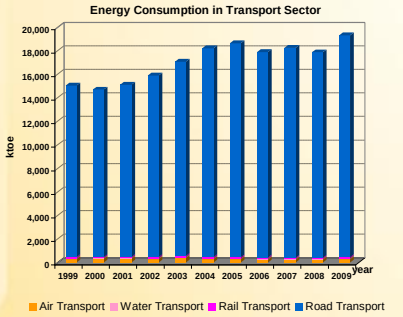
[1] Kamakate, F and Schipper, L. (2009), Energy Policy, 37, 3743-3751
[2] Schipper, L. et al (1997), Transportation Research D, 2(1), 57-76.
[3] IEA (2008), "Energy Technology Perspectives: Scenarios & Strategies to 2050", ISBN 978-92-64-04142-4

Macro level analysis

- Need two data sets MJ / ton-km
  - Fuel consumption in freight transport
    - ✓ Ministry of Energy only reports fuel sale
    - ✓ Need segmentation of fuel used in freight transport → Energy demand modeling
  - Economic activity (ton-km) in freight transport
    - ✓ Thailand transport portal







http://vigportal.mot.go.th/portal/site/PortalMOT/stat/total_about_transport/

Energy demand modeling

- End-use approach
  - Energy demand in road transport sector is calculated from a product of three important driving factors; total number of vehicle stock, average travel distance of vehicle and fuel consumption rate of vehicle.

$$ED_t = \sum_i^n \sum_j^m VS_{i,j,t} \times FAVKT_{i,j,t} \times FAFE_{i,j,t}$$

Where ED_t is the total energy demand in year t (MJ),
$VS_{i,j,t}$ is the total stock of vehicle type i which use fuel type j in in year t (vehicles),
$FAVKT_{i,j,t}$ is the fleet average annual vehicle kilometer of travel of fuel type j for vehicle type i in year t (kilometer), and
$FAFE_{i,j,t}$ is the fleet average on-road fuel economy of the fuel type j for vehicle type i in year t (MJ per kilometer).

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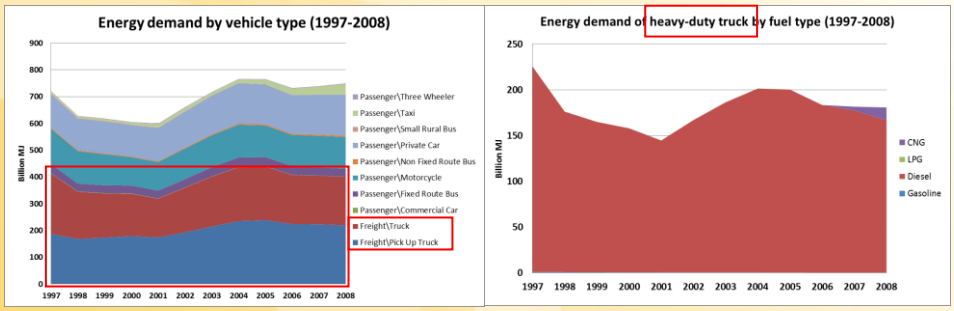
Energy demand modeling

- Results of energy demand by vehicle type (1997-2008)
- Energy demand of heavy-duty truck by fuel type (1997-2008)



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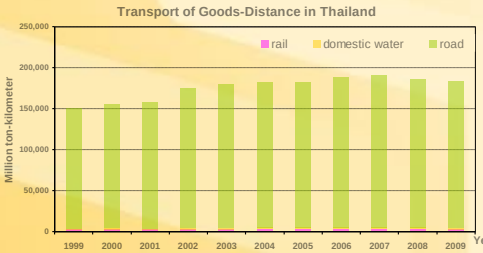
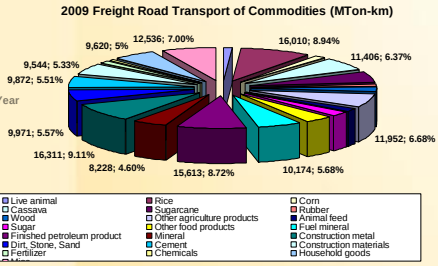
Ton-km database (source 1)

- Transport portal*
  - Categorized transportation data for various means (road, rail, water, ocean & air) over time

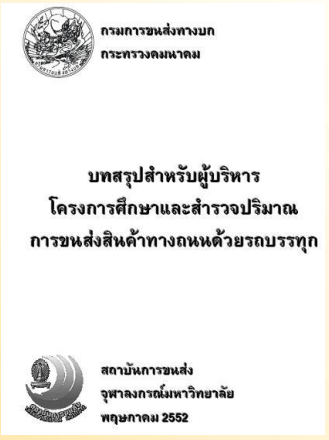




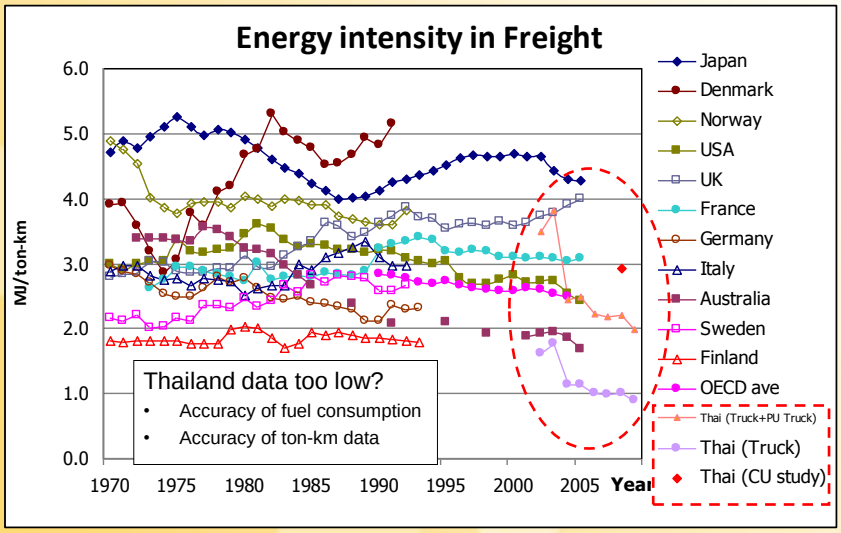
*http://vigportal.mot.go.th/portal/site/PortalMOT/stat/total_about_transport/

Ton-km database (source 2)

- Report by Transportation Institute, Chula Univ (2008-9)
  - Not implying as country average data!
  - Using **roadside interview survey** to estimate freight activity (ton-km) at major economic provinces e.g. Bangkok, Nakhon Sawan, Songkla, Nakhon Ratchasrima, Khon khaen and Chiangmai
  - Collect data at checkpoint
    - ✓ 2 days/week for weekday and weekend in Bangkok only (others 1 day/week)
    - ✓ 2 times/year to include harvesting season of major economic crops
  - Data collected consist of
    - ✓ starting point-destination point,
    - ✓ vehicles in each category,
    - ✓ type of carried products and mass.



Comparison with literature data[1,2,3]



[1] Kamakate, F and Schipper, L. (2009), Energy Policy, 37, 3743-3751
[2] Schipper, L. et al (1997), Transportation Research D, 2(1), 57-76.
[3] IEA (2008), "Energy Technology Perspectives: Scenarios & Strategies to 2050", ISBN 978-92-64-04142-4

Micro level analysis

- Case study from LTM* project with detailed info on
  - Vehicle characteristics: type, age
  - Weight of commodities carried
  - Distances traveled
  - Fuel consumed: diesel, CNG
- Analyzed data from
  - 12 participating logistic companies
  - 10 vehicle types:
    - ✓ trailer (24, 22, 20, 18, 10 wheels)
    - ✓ semi-trailer (22, 18 wheels)
    - ✓ truck (12, 10 wheels)
  - Various energy saving mechanisms
    - ✓ Radial tire, GPS, transmission improvement
  - Total of 216 vehicles database

ดำเนินการโดย
สำนักงานนโยบายและแผนพลังงาน กระทรวงพลังงาน
สถาบันพลังงานเพื่ออุตสาหกรรมแห่งประเทศไทย

*LTM = Logistic and Transport Management, http://www.ltmthailand.net/home_project.php

Energy/CO_2 intensity vs. weight carried

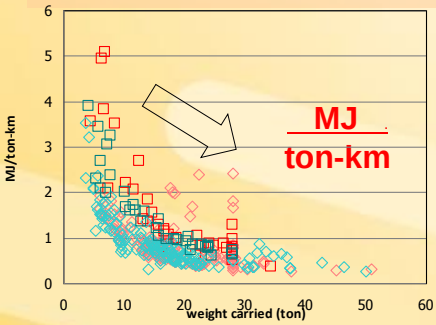


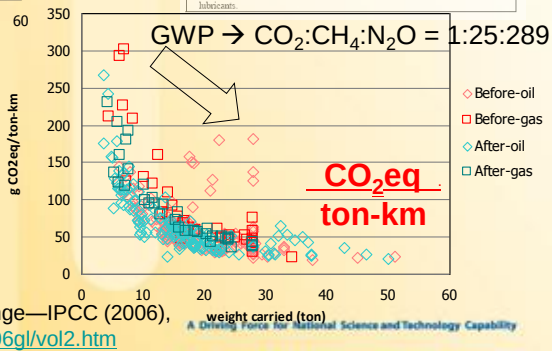
TABLE 3.2.1
ROAD TRANSPORT DEFAULT CO_2 EMISSION FACTORS AND UNCERTAINTY RANGES [a]

Fuel Type	Default (kg/TJ)	Lower	Upper
Motor Gasoline	69 300	67 500	73 000
Gas/ Diesel Oil	74 100	72 600	74 800
Liquefied Petroleum Gases	63 100	61 600	65 600
Kerosene	71 900	70 800	73 700
Lubricants [b]	73 300	71 900	75 200
Compressed Natural Gas	56 100	54 300	58 300
Liquefied Natural Gas	56 100	54 300	58 300

Source: Table 1.4 in the Introduction chapter of the Energy Volume.
Notes:
[a] Values represent 100 percent oxidation of fuel carbon content.
[b] See Box 3.2.4 Lubricants in Mobile Combustion for guidance for uses of lubricants.

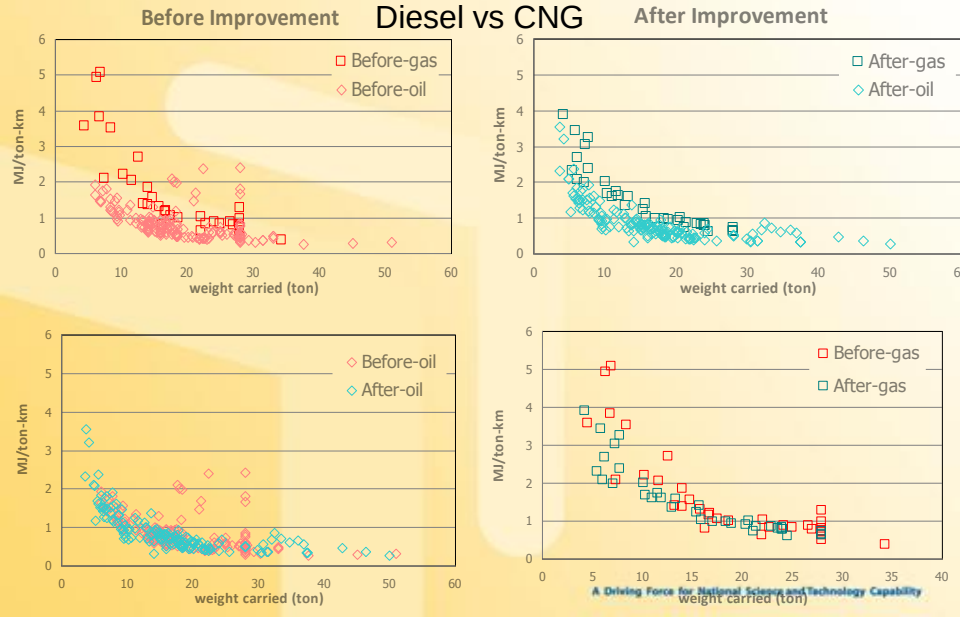
TABLE 3.2.2
ROAD TRANSPORT N_2O AND CH_4 DEFAULT EMISSION FACTORS AND UNCERTAINTY RANGES [a]

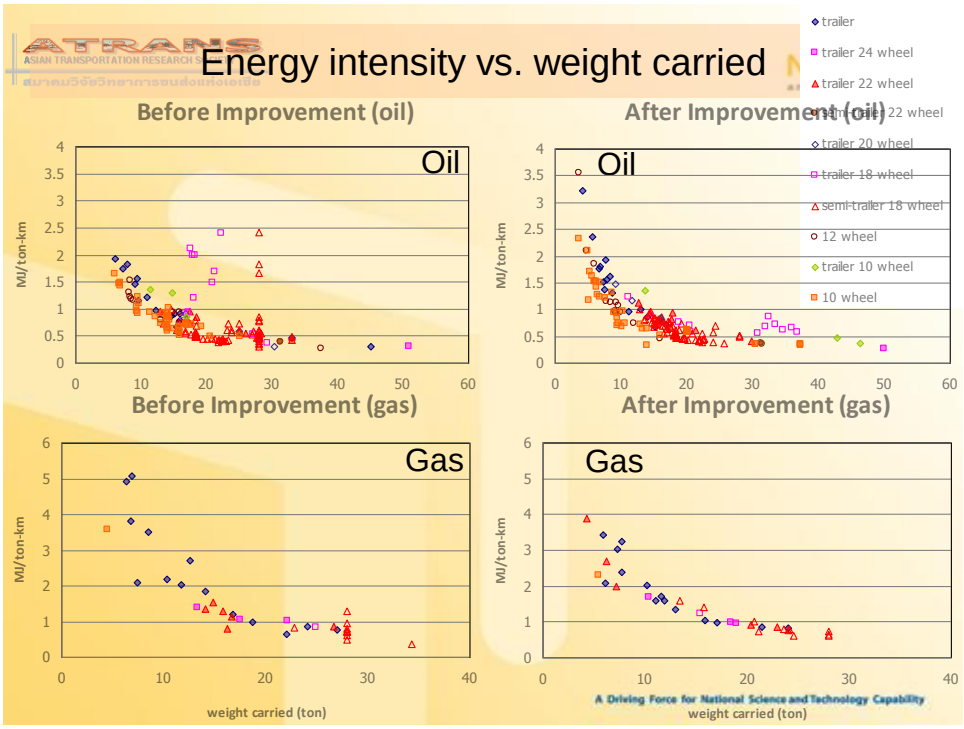
Fuel Type/Representative Vehicle Category	CH_4 (kg/TJ) Default	CH_4 Lower	CH_4 Upper	N_2O (kg/TJ) Default	N_2O Lower	N_2O Upper
Motor Gasoline -Uncontrolled [b]	33	9.6	110	3.2	0.96	11
Motor Gasoline –Oxidation Catalyst [c]	25	7.5	86	8.0	2.6	24
Motor Gasoline –Low Mileage Light Duty Vehicle Vintage 1995 or Later [d]	3.8	1.1	13	5.7	1.9	17
Gas / Diesel Oil [e]	3.9	1.6	9.5	3.9	1.3	12
Natural Gas [f]	92	50	1 540	3	1	77
Liquified petroleum gas [g]	62	na	na	0.2	na	na
Ethanol, trucks, US [h]	260	77	880	41	13	123
Ethanol, cars, Brazil [i]	18	13	84	na	na	na



Intergovernmental Panel on Climate Change—IPCC (2006), http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.htm

Effect of Fuel & Fuel-saving mechanism




Energy intensity vs. weight carried
Before Improvement (oil)
After Improvement (oil)
Oil
Before Improvement (gas)
After Improvement (gas)
Gas
MJ/ton-km
weight carried (ton)
trailer
trailer 24 wheel
trailer 22 wheel
semi-trailer 22 wheel
trailer 20 wheel
trailer 18 wheel
semi-trailer 18 wheel
12 wheel
trailer 10 wheel
10 wheel
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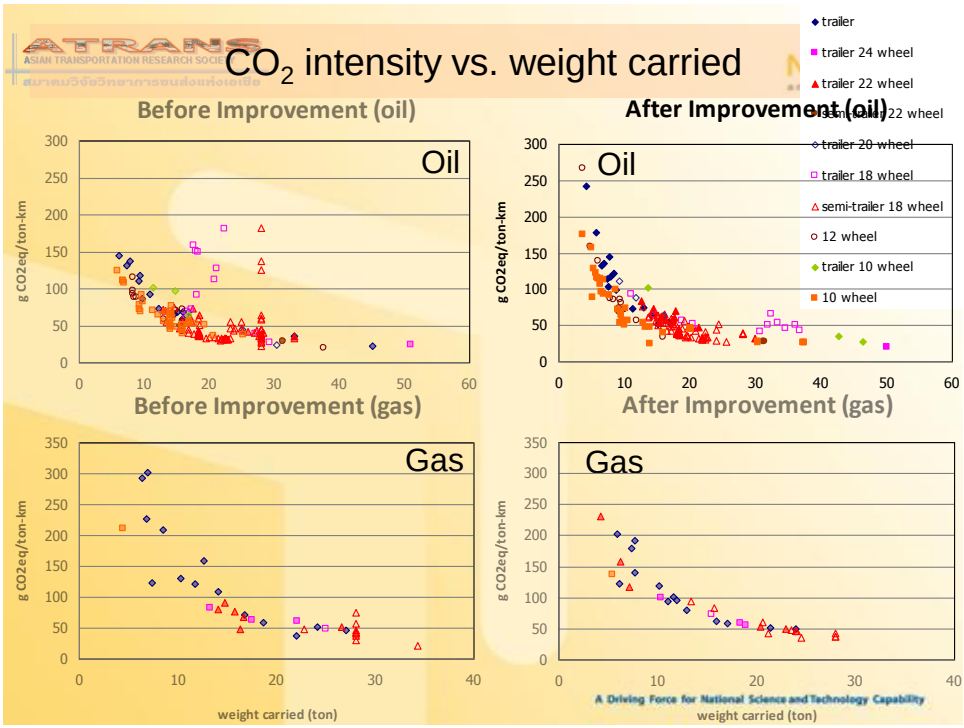
CO2 intensity vs. weight carried
Before Improvement (oil)
After Improvement (oil)
Oil
Before Improvement (gas)
After Improvement (gas)
Gas
g CO2eq/ton-km
weight carried (ton)
trailer
trailer 24 wheel
trailer 22 wheel
semi-trailer 22 wheel
trailer 20 wheel
trailer 18 wheel
semi-trailer 18 wheel
12 wheel
trailer 10 wheel
10 wheel
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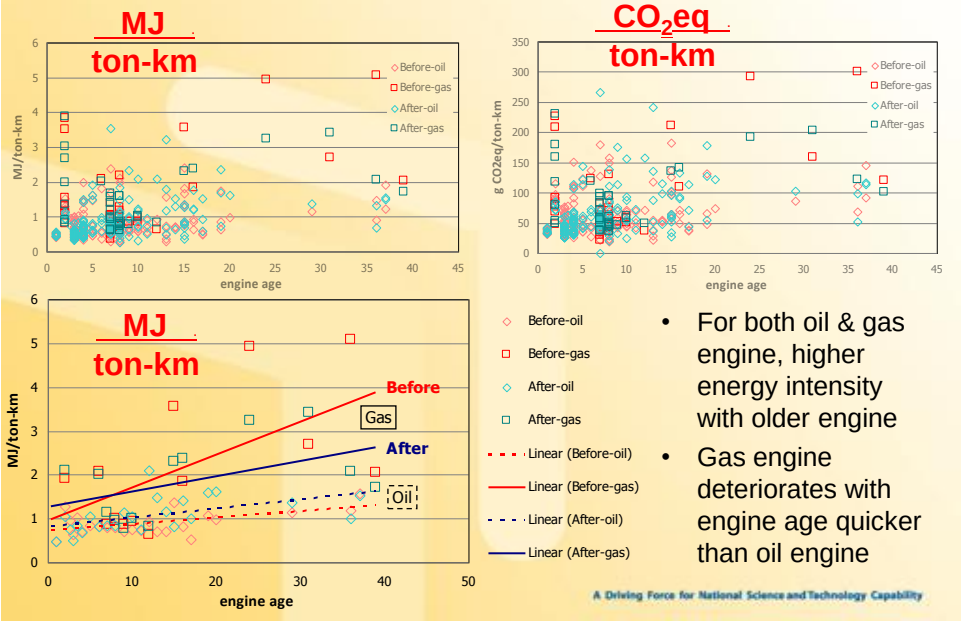
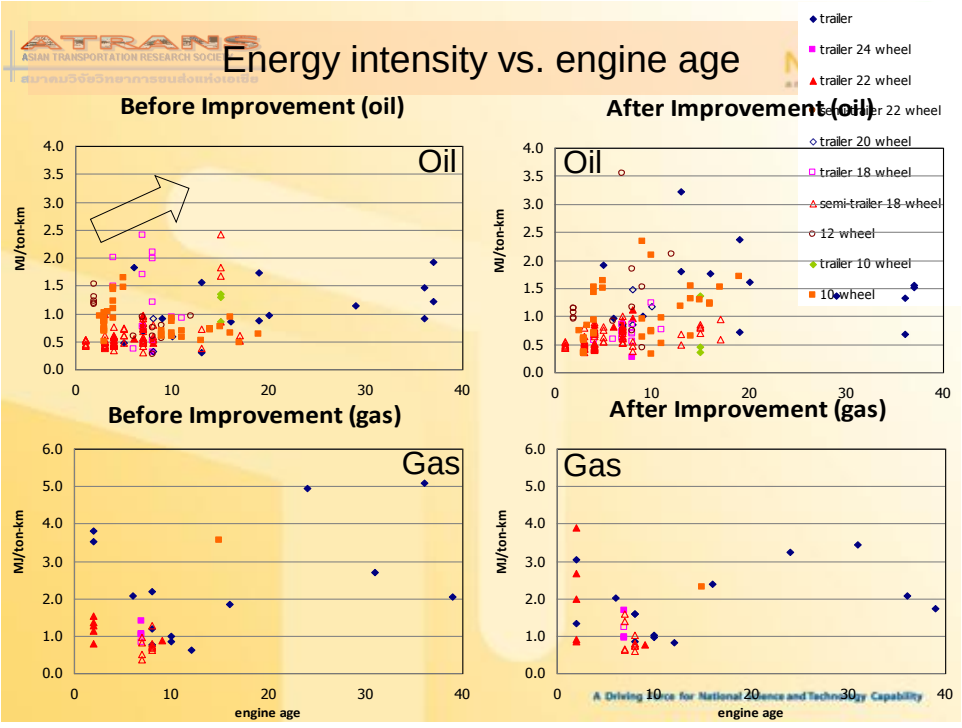
Energy/CO_2 intensity vs. engine age

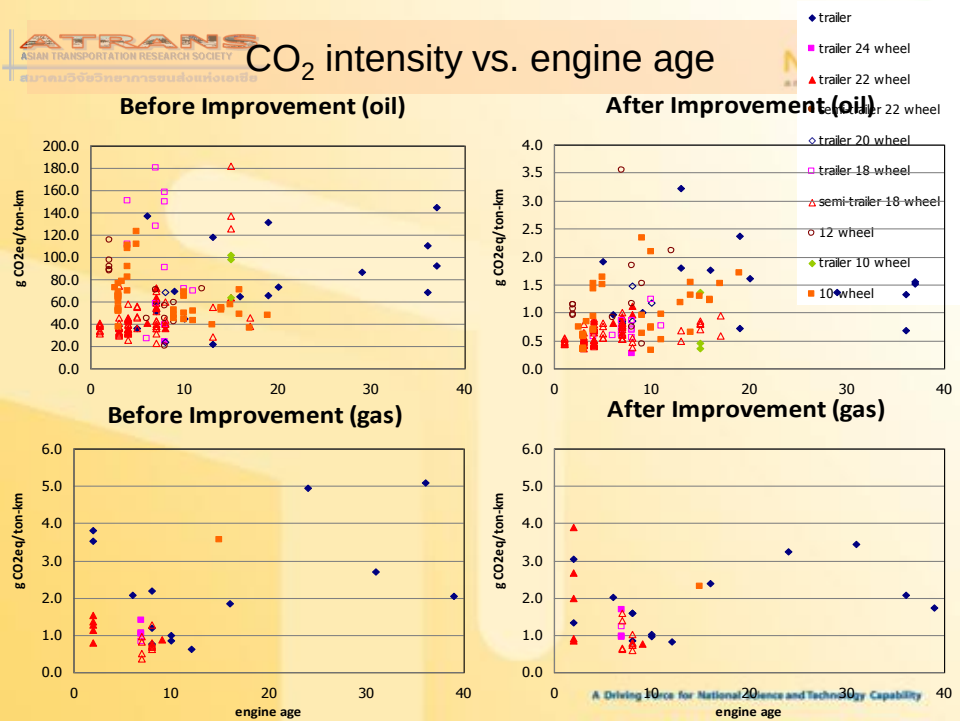


- For both oil & gas engine, higher energy intensity with older engine
- Gas engine deteriorates with engine age quicker than oil engine

Energy intensity vs. engine age



CO_2 intensity vs. engine age



Conclusions

- Energy/CO_2 intensities are crucial parameter for monitoring and goal setting
- Macro analysis
  - Need consistent proper data recording: fuel consumed for transporting goods & economic freight activity (ton-km)
  - Current fuel consumption in transportation needs segmentation for people vs. freight
- Micro analysis
  - Less energy intensity (MJ/ton-km) for
    - ✓ larger weight carried
    - ✓ diesel than CNG due to higher efficient CI engine for diesel (rather than SI engine for CNG)
    - ✓ newer engine
  - Potential for improving energy intensity in freight (truck) transport via various mechanisms
- Offers some baseline figures for energy intensity in Thai freight transport by truck