出國報告（出國類別：考察）

出席 2007 年底特律汽車工程學會年會及考察車輛污染相關管制策略與實務

服務機關：行政院環境保護署

姓名職稱：高增新技正

派赴國家：美國

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摘要

面臨國內機動車輛嚴重污染都會區環境品質，以及全球暖化日益嚴重問題，藉由與我國自動機工程學會(SAE TAIPEI)舉辦的「2007 SAE 考察團」，與國內產、官、學、研共 35 人，於 96 年 4 月 11 日至 4 月 21 日一起參訪 2007 年 SAE(Society of Automotive Engineering)美國年會，並拜訪美國三大汽車廠，及與車廠產業精英分享最新車輛製造技術及製造策略，進行溝通，作爲我國管理之借鏡，並建立日後合作關係。

於 2007 年美國汽車工程學會年會暨展覽會之論壇，歐美日車廠皆一致提出研究數據，並表示混合動力車(hybrid vehiccle)是最能立即減少 CO2 及空氣污染物排放之實際解決方法，且據 2007 年 4 月 12 日當地 USA TODAY 報紙刊載，雙燃料混合車技術已商業化，運用在美國的火車、公車、校車、箱形客貨兩用車、拖船、挖土機等建築工具等訊息，顯示未來混合動力車將是世界汽車工業發展及競爭重點。

我國應善用現有的技術，制訂有效政策，導引提昇燃料效率、鼓勵民眾使用混合動力車輛，減少車輛污染排放，且應及早規劃國內使用電動車、油電混合車和氫動力車之發展計畫，主動輔導國內車廠與國外業者合作，研發、代工，製造出兼具實用、安全以及對地球環境友善的新世代車輛，維持國際競爭力，振興國內經濟，並提昇國內生活品質。

目　　錄

壹、　目的

我國地狹人稠，至 94 年底汽機柴油車高達 1,986 萬輛，平均每 4 人就有一輛汽車，密度高居亞洲第二，平均每二人就有一輛機車，密度高居亞洲第一，汽機柴車排放之空氣污染物，尤其對都會地區空氣品質造成嚴重影響。因此，本署過去除了在油品方面進行改善，並加嚴車輛空氣污染物排放管制標準，未來如何有效藉著交通管理、管制措施，來增加符合環保動力之大眾捷運工具使用，降低私人車輛成長，以減少移動污染源的排放量，是本署未來加強改善污染的努力方向。

鑒於近年來社會快速工業化，大量使用化石燃料結果，全球二氧化碳排放量比過去 200 年增加 30%，全球平均溫度增加攝氏 1.4 度，全球暖化結果引起氣候異常，各地都出現天氣不夠冷、雪不夠多的狀況，甚至花序錯亂，侯鳥不隨季節遷徙的現象，因此當務之急是從改善空氣品質著手，但是就台灣車輛數量在十數年間從 1200 萬台攀昇至 2000 萬台的情形來看，要減少車輛二氧化碳排放，是一個極大的挑戰任務。

美國是全世界最大的汽車消費市場，美國嚴格的法令已經迫使美國汽車工業，包括美國的三大車廠以及日本車廠，兢兢業業地展開一場汽車的「綠色革命」。底特律是美國三大車廠(福特、通用、克萊斯勒)、全球前五大之二零組件廠—Delphi、Visteon 總部所在，一年一度的底特律汽車工程學會(SAE,Society of Automotive Engineering)美國年會，邀集世界汽車產業精英、專家學者，發表最新技術、具競爭力之高科技車輛及發展策略，供世界汽車產業觀摩參考，是汽車產業一大盛事。

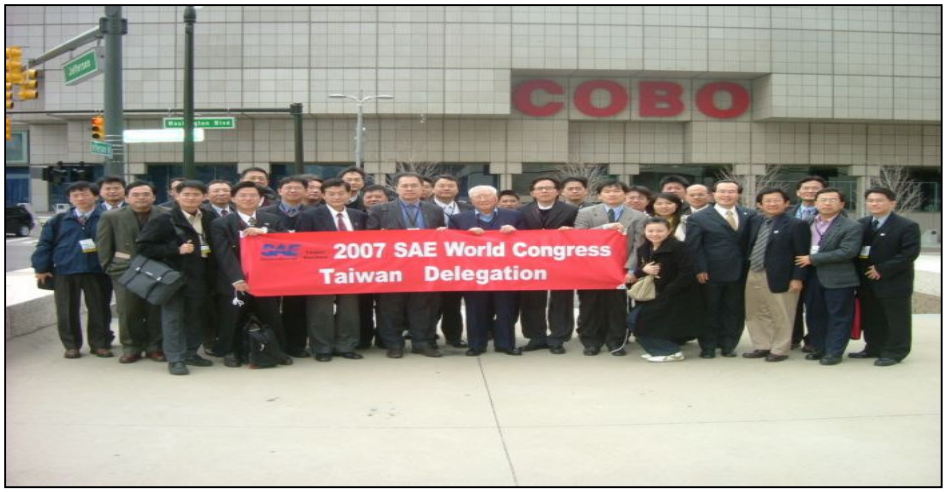
因此，透過參加我國自動機工程學會(SAE TAIPEI)舉辦的「2007 SAE 考察團」，與國內產、官、學、研共 35 人，一起參訪 2007 年美國汽車工程學會年會暨展覽會(2007 SAE World Congress)，及三大汽車廠，並與車廠產業精英分享最新環保車輛製造技術及環保策略，並進行溝通，作爲我國規劃加強管理之評估依據，並建立日後交流合作關係，俾善用現有的技術，制定有效政策，導引提昇燃料效率、鼓勵民眾使用混合動力車輛，以減少車輛污染排放，並促進產業升級，與國際接軌，提昇國際競爭力。

貳、 過程：

一、行程：

本〈96〉年參加中華民國自動機工程學會(SAE TAIPEI)舉辦的「2007 SAE 考察團」，於 96 年 4 月 11 日至 4 月 21 日經駐芝加哥台北經濟文化辦事處，以及密西根國建學術聯誼會協助，圓滿完成 SAE 年會等參訪活動。活動行程如下：

項次	活　動　內　容
一	出席 2007 年美國汽車工程學會年會暨展覽會
二	參訪美國前三大車廠及一階 OEM 大廠
三	參訪密西根大學吳賢明製造研究中心(WuMRC)及車輛研究中心(ARC)
四	出席密西根國建會技術研討會
五	參加 SAE international Reception 等活動



SAE 年會於底特律市區 COBO center 舉行

二、 活動內容

〈一〉  出席 2007 年美國汽車工程學會年會暨展覽會

2007 年美國汽車工程學會年會暨展覽會(2007 SAE World Congress)，於本(96)年 4 月 16 日至 19 日，在底特律市的科博會議展覽中心舉辦，每年舉辦一屆，至今已有 50 多年的歷史。它是由具有百餘年歷史，並在 97 個國家擁有 90000 多名會員的美國汽車工程學會組織的當今世界上最具權威的汽車業盛會，是目前世界上最大的汽車專家年會，也是世界各國頂級汽車製造商及配件商的年度交流盛會。

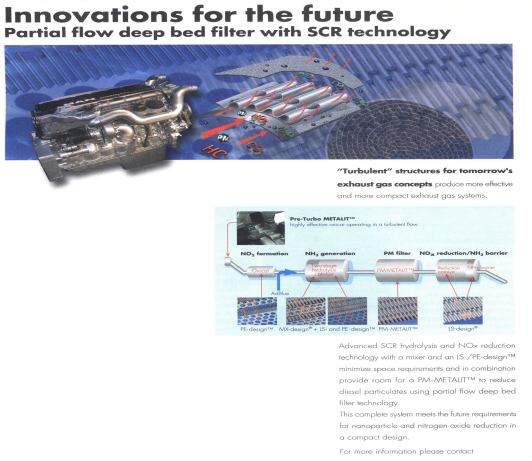
SAE WORLD CONGRESS 是國際公認的最具權威性的汽車零部件及其相關工業、相關技術的展覽會，該展覽會針對北美的配套市場，不僅對北美地區的汽車配套市場有重大影響，更主要是對汽車整車及零部件的製造、銷售、生產配套及零部件的開發、發展等具有權威性的影響。每年都吸引世界各地的主要汽車公司及零部件製造企業前往參展，世界各地有關的商務界、技術界的眾多權威人士及企業的決策人士等也都專程到會參觀、交流、洽談。共有來自全球的千餘家企業亮相於大會，集中展示了當今世界汽車工業最前沿的理念與技術，詮釋了世界汽車工業發展動向。

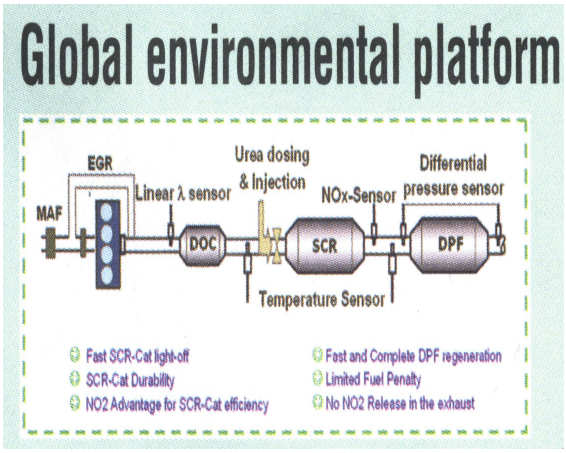
2007 年美國汽車工程學會年會暨展覽會在美國底特律科博(COBO)會議展覽中心舉辦，分三大議題探討最新的解決方案技術，包括混合動力技術、汽車安全與實驗技術，以及汽車電子技術應用，在論壇上包括通用汽車公司總裁里克瓦格納在內的汽車公司領導人都表示，替代能源將成爲他們未來商業戰略的主要議題。

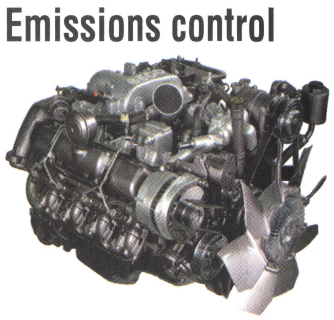
現場展示項目包含各類汽車零配件、發動機、安全帶、製動器零件、底盤、離合器、面板、設備、配套、儀表、冷卻系統、蓄電池、環保廢物處理、傳動及變速器、提升設備、服務設備、調試設備、專用工具、修理設備、汽車電器、音響、電子設備、空調、防盜產品、汽車燈具、汽車裝飾用品、輪胎及

車輪、運輸車輛，並因應 CO2 減量國際協定與環保需求，特別設置環境保護展覽區，展示技術成熟之氫氣燃料車、油電混合動力、電動車、燃料電池車及相關材料，有助於汽車業者參考製造出兼具實用、安全及符合政府

環保標準之車輛，照片如下。







〈二〉參訪美國前三大車廠及一階 OEM 大廠

拜訪美國 Ford、GM、DC 汽車大廠，深切了解美國整車廠研發及技術走向，使團員不禁讚嘆全球前三大汽車廠在技術研發與設備的領先。因目前對替代能源需求提高，安排參訪在太陽能板產業首屈一指的 UNITED SOLAR OVONIC，藉由當地華人主管親自帶領參觀廠房，及介紹製造流程，使團員對於太陽能板的技術及應用更加明白，並對於太陽能板所能發揮的效益及對地球資源善加利用感到非常有興趣。

於 Uni-Solar Ovonic 合照

另外安排參觀第一階 OEM 大廠 Arvin Meritor，Arvin Meritor 主要提供 CVS(commercial Vehicle System)以及 LVS(Light Vehicle System)之整合性解決方案，該公司全球設有 112 個製造據點，員工遍及全球達到 27,500 人，其所專門設立的展示館，呈現自主研發的零組件及系統件，對於行銷該公司不遺餘力，也讓在場來賓除了對於如此大型的全球企業印象深刻外，也反思台灣廠商更應積極進行全球行銷，讓別人認識自己，才有機會把產品外銷，把市場的餅擴大 。

〈三〉拜訪密西根大學吳賢明製造研究中心(WuMRC)和車輛研究中心(ARC)

吳賢明製造研究中心(S.M. Wu Manufacturing Research Center; WuMRC)及車輛研究中心(Automotive Research Center; ARC)，爲密西根大學最著名的兩間實驗室，其中 WuMRC 爲全北美最大之工具機實作實驗室，研究領域著重於生產製造工具、流程和方法。ARC 則與各北美車廠有密切合作，許多研究經費大都由車廠直接資助。

Albert Shih 教授和 Huei Peng 教授簡介密西根大學研究現況，並帶領參觀其實驗室，使大家瞭解學界在研究方面的實際狀況，並對於此兩研究中心與車廠合作研發工作，有更深入了解與認知。

WuMRC 實驗室參觀

ARC 實驗室參觀

密西根大學研究現況簡介

〈四〉出席密西根國建會技術研討會

密西根國建學術聯誼會邀請七位在不同車輛領域之專家，就當前汽車業最熱門的話題，發表他們的見解：

1. Dr. Andrew Brown 介紹決定未來車輛產品組合的流程，由全球主要趨勢開始，找出發展藍圖，為成功的產品，此點除值得研發單位的參考，並可作為日後規劃政策之參考。
2. 吳鳴成博士則大聲疾呼替代能源的急迫需求，預估 2020 年後石化燃料存量將不敷能源需求。
3. 彭暉博士也強調由於石化燃料有限、溫室效應控制，未來個人運輸工具勢必重新設計以使用再生能源，混合動力系統也不只限於油電混合車，將來會廣泛應用於任兩種不同的動力來源，更有效率使用能源。
4. 陳咸亨博士廣泛討論車輛動態控制系統，這些系統主要功能為加強車輛操控穩定性，避免危險情況發生。
5. 傅德偉博士則介紹開發車輛控制系統所需工具：即時參數資料量測、即時感測器/致動器相關性分析和即時讀取/修改控制器參數，奇表示新的 ECU 調校通訊協定可使開發中 ECU 就相當於量產 ECU。
6. 顏世榮專家介紹舊產品創新設計的方法：此方法可完成減重與高強度的創新設計。
7. 丘萬里專家則談到如何對應品質的挑戰，品質的演進從零缺陷、滿足設計規範、滿足基於顧客要求的設計規範、到能吸引並讓顧客興奮的外在特質，品質問題的根源是「差異因素」，愈早考慮差異因素，儘早採取措施，愈能節省量產開支。
8. 本研討會內容相當豐富，讓我們從不同面向了解未來車輛產業的發展，也可作為未來車輛中心研發參考以及追蹤產業趨勢的基準。

〈五〉參加 SAE International Reception 等活動

積極參與在 Detroit 之車輛產業商業活動以建立人脈並宣揚車輛中心的名聲，例如參加台灣之夜活動以及亞太商業協會(Asian Pacific American Chamber of Commerce)，以及 SAE international Reception,藉此與海內外汽車專業領域相關人士建立起良好友誼關係，認識其他國家的 SAE 代表團員，搭起各國產業知識交流的橋樑以及發展潛在商機。

與當地政府官員、市議會議員、國建會代表及僑領合影

底特律市議長亦參與盛事致詞

〈三〉參加團員

	服務機關	姓名	職稱	部門
1	華創車電技術中心股份有限公司	左自生	副總經理	車身工程部
2	華創車電技術中心股份有限公司	王立中	經理	車身工程部
3	華創車電技術中心股份有限公司	馮業誠	工程師	動力底盤部
4	華創車電技術中心股份有限公司	陳榮貴	副理	電子電機部
5	華創車電技術中心股份有限公司	邱俊銘	組長	整車工程部
6	中華民國自動機工程學會	謝強中	副秘書長	秘書處
7	中華民國自動機工程學會	劉怡君	秘書	秘書處
8	財團法人車輛研究測試中心	黃隆洲	總經理	中心本部
9	財團法人車輛研究測試中心	王正健	經理	國際合作發展部
10	財團法人車輛研究測試中心	李盈逸	副管理師	國際合作發展部
11	財團法人車輛研究測試中心	周維果	經理	專案辦公室
12	財團法人車輛研究測試中心	葉智榮	工程師	研發處底盤系統發展專案
13	財團法人車輛研究測試中心	林彥呈	工程師	電子檢驗課
14	財團法人車輛研究測試中心	潘國良	課長	振動噪音課
15	財團法人車輛研究測試中心	許文賢	專員	研發處智慧系統發展專案
16	中華汽車工業股份有限公司	巫賢榮	課長	電機電子部
17	中華汽車工業股份有限公司	林嘉昱	專員	產品工程部
18	光陽工業股份有限公司	陳俊雄	工程師	研發一部
19	光陽工業股份有限公司	林光榮	工程師	研發一部
20	三陽工業股份有限公司	彭德禮	主任研究員	研究發展中心研究室
21	三陽工業股份有限公司	林朝生	主任	研究發展中心設計室
22	財團法人台灣電子檢驗中心	古元富	組長	電磁一部
23	國瑞汽車股份有限公司	廖振成	Group 長	第一研發部

24	國瑞汽車股份有限公司	洪文庶	Group 長	第一研發部
25	工業技術研究所	孫立德	董事長	
26	堤維西交通工業〈股〉公司	黃競賢	襄理	技術研究所
27	堤維西交通工業〈股〉公司	王冠文	課長	計畫管理部
28	福特六合汽車股份有限公司	丘應瑞	經理	福特政府事務部
29	工業技術研究所	陳麗芬	產業分析師	先進運輸部
30	歐立車材製造股份有限公司	陳顯榮	負責人	
31	高苑科技大學	張學斌	院長	電機學院
32	環保署	高增新	技正	空保處
33	拓樸科技股份有限公司	謝佳宸	研究員	流行趨勢部

參、心得

全球暖化日益嚴重，以及能源問題，據美國環保署發佈 2007 年溫室氣體盤查結果，運輸系統 CO2 排放量占燃用石化燃料設施 CO2 排放總量 33%，係主要 CO2 排放源，且美國加州州長阿諾史瓦辛格於 96 年 1 月 18 日發布實施「低碳燃料標準」，是全球第一份限制燃料中含碳量的行政命令，估計將使低碳燃料取代車輛 20%之汽油量，另外，紐約市長亦於 96 年 5 月 23 日宣布要在五年內，把紐約市現在燃用汽油的計程車，全部改成油電混合動力的環保車，並將分階段進行，每年以百分之 20 的幅度增加，一直到 2012 年全部完成，配套計畫還包括明年十月以後，新計程車必須達到每公升汽油至少行駛十公里的標準，一年之後，提升到 13 公里，紐約市目前有一萬三千輛計程車。顯示日後電動車、油電混合車和氫動力車的發展，勢必更具競爭力，我國宜及早規劃，引導國內汽車業者引進或製造替代燃用石化燃料或混合動力系統之車輛，以保持國際競爭力，並改善我國環境品質。

隨著汽車總量的不斷增長，當務之急就是減少 CO_2的排放。地小人稠的台灣，大眾運輸系統對於暖化問題非常重要，包括運輸動線密度、載客輛高的公車系統，應優先納入落實溫室氣體減量的管制對象。

面臨國際油價調漲，增加公車營運成本；爲了節省支出，並同時降低汙染，引進低污染公車成爲各縣市公民營業者規畫的大方向，政府機關應提供相關配套措施，鼓勵公民營業者積極汰舊換新營運車輛，以創造營運新契機，並提昇環境生活品質。

肆、建議事項

一、 建議我國應善用現有的技術，制定有效政策，導引提昇燃料使用效率，及鼓勵民眾使用混合動力車輛，以降低車輛污染排放量。

二、 建議需有相關配套措施，例如釋出利多鼓勵計程車將燃油更換爲使用天然氣、或改用油電混合、或其他符合環保之替代能源車輛。

三、 全球暖化日益嚴重，以及能源日漸枯竭等問題，我國應及早規劃國內使用電動車、油電混合車和氫動力車之發展計畫，主動輔導國內車廠與國外業者合作，研發、代工，製造出兼具實用、安全以及對地球環境友善的新世代車輛，維持國際競爭力，振興國內經濟，並提昇國內生活品質。

伍、附件

FINAL

The Role of a Low Carbon Fuel Standard in Reducing Greenhouse Gas Emissions and Protecting Our Economy

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Executive Summary

Transportation accounts for more than 40% of California's annual greenhouse gas (GHG) emissions and the state relies on petroleum-based fuels for 96 percent of its transportation needs. Petroleum use contributes to climate change and dependency on oil leaves workers, businesses and consumers vulnerable to price shocks from an unstable global energy market. No business should be hostage to a single supplier for its most critical raw materials; neither should any state or nation. To protect our jobs and wages, clean our air and maintain our way of life, we must diversify our fuel sources and reduce our reliance on oil.

As one of the world's largest energy consumers and the national leader in energy efficiency,alternative energy and greenhouse gas reduction, California has the opportunity and ability to diversify its transportation fuel supplies, decrease the greenhouse gases emitted from those fuels, and establish a sustainable market for cleaner-burning fuels. Accordingly, by Executive Order the Governor will establish a first-of-its-kind policy to reduce the greenhouse gas impact from California's use of transportation fuels and in so doing diversify the state's transportation fuels portfolio.

Specifically, the Executive Order will establish:

1. A Low Carbon Fuel Standard (LCFS) for transportation fuels sold in California, and
2. An initial LCFS goal of reducing the carbon intensity of California's passenger vehicle fuels by at least 10 percent by 2020.

The LCFS is the world's first global warming standard for transportation fuels, and as with other groundbreaking California policies, it may serve as a model for state, federal and international standards. This historic action will reduce California's reliance on fossil fuels and help the state reach its AB 32 emissions targets.

The LCFS will require fuel providers[1] in California to ensure that the mix of fuel they sell into the California market meet, on average, a declining standard for GHG emissions measured in CO_2-equivalent gram per unit of fuel energy sold. The standard will be measured on a lifecycle[2] basis in order to include all emissions from fuel consumption and production, including the "upstream" emissions that are major contributors to the global warming impact of transportation fuels.

In order to realize these GHG reductions at the lowest cost and in the most consumer-responsive manner, the LCFS will utilize market-based mechanisms to allow providers to choose how they reduce emissions while responding to consumer demand. For example, providers may purchase and blend more low-carbon ethanol into gasoline products, purchase credits from electric utilities supplying

low-carbon electrons to electric passenger vehicles, diversify into low-carbon hydrogen as a product and more, including new strategies yet to be developed.

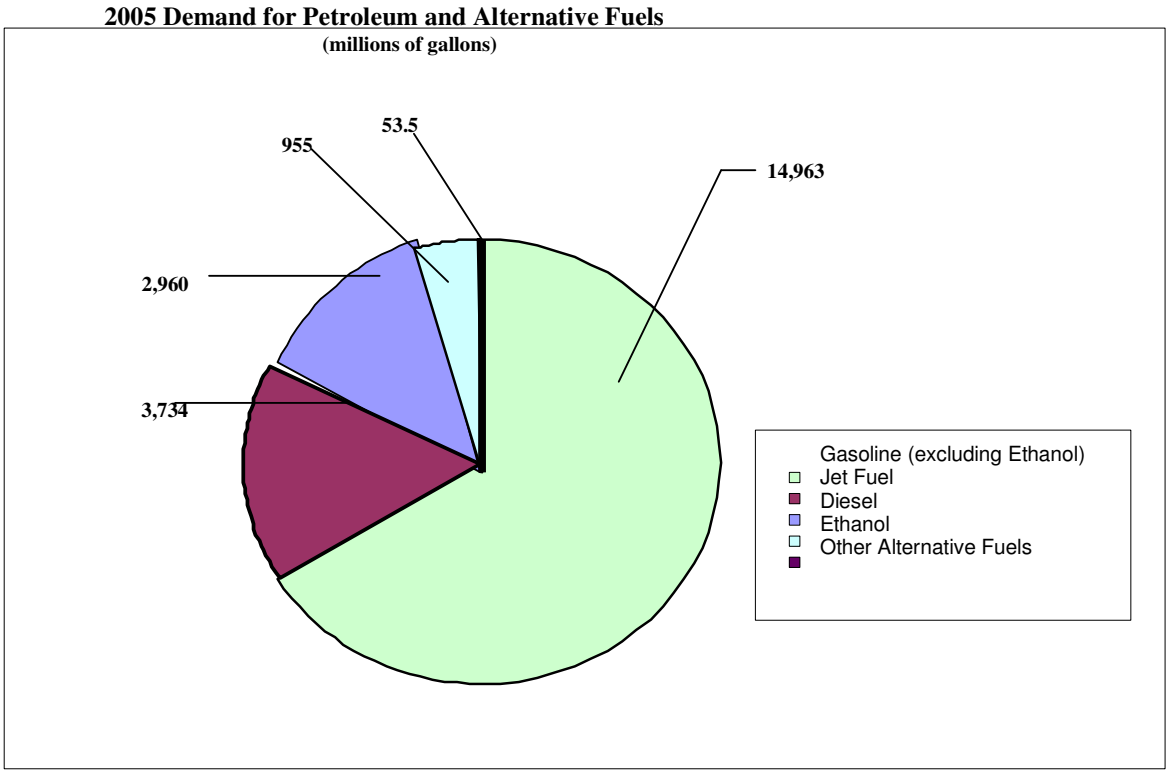
By 2020, the LCFS will produce a 10 percent reduction in the carbon content of all passenger vehicle fuels sold in California. This is expected to replace 20 percent of our on-road gasoline consumption with lower-carbon fuels, more than triple the size of the state's renewable fuels market, and place on California's roads more than 7 million alternative fuel or hybrid vehicles (20 times more than on our roads today).FINAL

Rationale for Policy

Low Carbon Fuels Support the Goals of Diversifying Fuel Supply and Reducing Greenhouse Gases

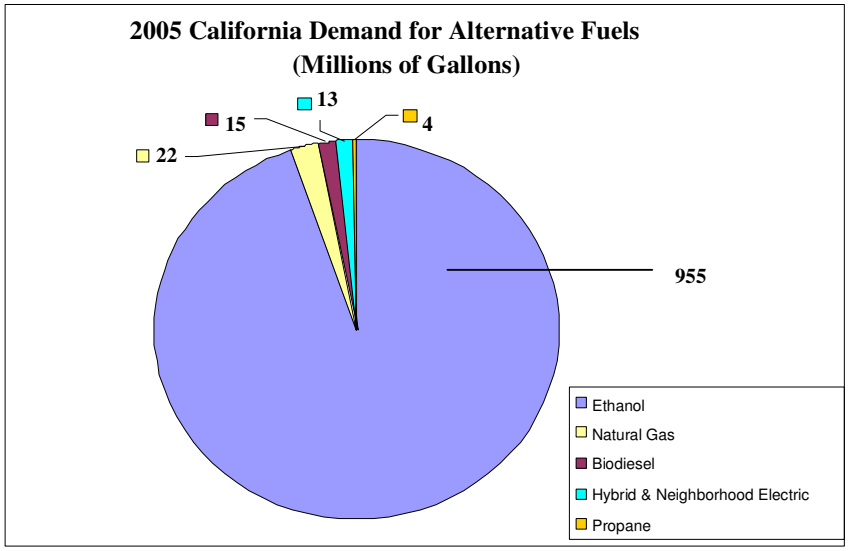
Diversify fuel supply. California relies excessively on one fuel to meet its transportation needs. Figure 1 demonstrates that petroleum-based fuels supply 96 percent of California's transportation needs. The other four percent is a combination of various alternative fuels (see Figure 2). Fuel diversity has been identified as a major policy objective in the CEC's *2003 Integrated Energy Policy Report*[3] and the Governor's BioEnergy Executive Order S-06-06 and Bioenergy Action Plan[4].

Figure 1



Sources: California State Board of Equalization Taxable Motor Fuel Sales, and CEC PIIRA database.

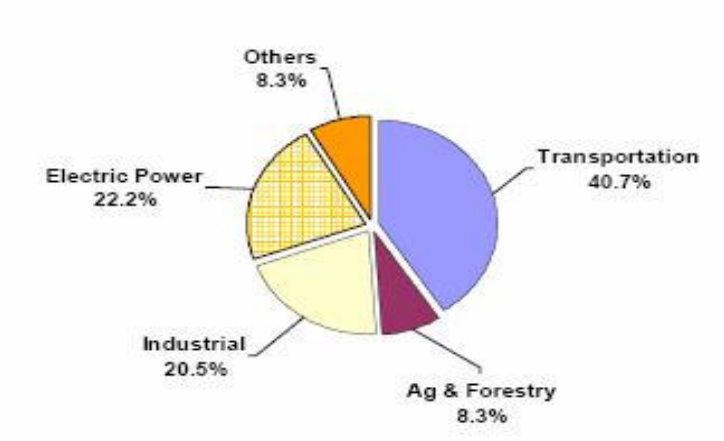
Figure 2



Sources: Analysis of California State Board of Equalization taxable gasoline sales figures and CEC data.

Reduce GHG emissions. Large-scale use of lower-carbon transportation fuels is necessary to meet the AB32 requirement that GHGs generated in the state be reduced to 1990 levels by 2020. Transportation fuels are responsible for over 40 percent of annual greenhouse gas emissions in California (Figure 3).

Figure 3 – Greenhouse Gas Emission Inventory - 2005



A Low Carbon Fuel Standard Allows Markets, not Governments, to Determine the Lowest Cost Path to Achieving the Goals and Meeting Consumer Demand

Regulatory certainty promotes development of low carbon fuels and new energy industries. The LCFS provide certainty to the growing clean energy market that sustainable markets for their products will exist but does so in a manner that does not select which alternative fuels will prevail in the marketplace. Technology and other companies then compete with one another to

sell into that market, allowing price and quality considerations to determine eventual winners. Reducing risk through regulatory certainty is also a benefit to energy companies.[5]

Expands consumer choice. The LCFS will communicate to producers and consumers that the GHG reduction requirements of AB32 will be met by *expanding* rather than limiting consumer choice. Because consumers will continue to seek the lowest prices for their transportation fuels and the new standard will allow fuel providers to meet its requirements in a flexible and consumer-responsive manner, the LCFS will inspire competition among creators and suppliers of low-carbon products seeking to sell their products to fuel providers needing to meet the new standard.[6]

The Design of a Low Carbon Fuel Standard[7]

A Performance-based Standard with Averaging, Banking and Trading

The LCFS will require fuel providers (defined as refiners, importers, and blenders of passenger vehicle fuels) to ensure that the mix of fuel they sell into the California market meets, on average, a declining standard for GHG emissions measured in CO_2-equivalent gram per British Thermal Unit (BTU).[8] All relevant greenhouse gases will be included (i.e., CO_2, CH_4, and N_2O) and be measured on a "full fuel cycle" basis (i.e., upstream feedstock extraction, fuel refining, and transport to market).[9]

Each fuel provider will need to demonstrate, on an annual basis, that the fuel mix provided to the market met the standard, including if necessary, by using credits previously banked or purchased. Providers of fuels that exceed the performance standard for the compliance period will be able to generate credits in proportion to the degree of over performance and the quantity of fuel provided. These credits can be banked for future use[10] or sold to other regulated fuel providers. Penalties for noncompliance will be determined during the Implementation Process (see below).

Numerous studies have demonstrated that performance-based standards drive least cost compliance by catalyzing unanticipated innovations.[11] Examples include the national Acid Rain Trading Program and the California Low Emission Vehicle program. With both of these programs, the actual cost of compliance was much lower than predicted by regulators. For example, in the case of the Acid Rain Trading Program, actual compliance costs were roughly one-third to one-half of those estimated in the first five years, saving an estimated $350 million to $1,400 million per year.[12]

Options for Compliance

Under the LCFS, fuel providers will have at least three different options with which to comply:

- Blend or sell an increasing amount of low-carbon fuels (for examples, see Table 1)
- Use previously banked credits
- Purchase credits from fuel providers who have earned credits by exceeding the standard.

One of the critical benefits of this performance-based approach is that it does not dictate the mix of fuels that fuel providers are obligated to deliver. Fuel providers will have flexibility to choose what types of fuels in what volumes they sell as long as their sales-weighted average meets the standard. In this way, the market will determine the least-cost and most consumer-responsive outcome for the fuel mix while ensuring decreasing GHG emissions.

Table 1. Possible Low Carbon Fuel Strategies

Low Carbon Fuel Strategy	Description
E10 (10% ethanol, 90% gasoline by volume)	Increase blending of ethanol from today's 5.7 percent by volume to 10 percent.
E85 (85% ethanol, 85% gasoline by volume)	Sell high blend ethanol (85 percent ethanol, 15 percent gasoline) for use in Flex Fuel Vehicles (FFVs).
Switch to Low-Carbon Ethanol	Switch to ethanol made from cellulosic materials (e.g., agricultural waste, switchgrass)l that has 4-5 times lower GHG emissions than today's corn.
Electricity	Either in pure battery electric vehicle or in plug-in hybrid vehicle that can be recharged from the electricity grid.
Hydrogen	Used in zero-emitting fuel cell vehicles or internal combustion engine cars modified.
CNG, LPG	Compressed Natural Gas and Liquefied Petroleum Gas burned in modified internal combustion engine cars.
Other biomass based fuels	For example, BP and Dupont are developing biobutanol as a possible additive and Chevron is exploring petroleum-like products synthesized from biomass (so-called "biocrude")
Other	Future strategies to be developed by fuel providers and outside innovators.

Basis for 10 Percent Reduction Target

10 percent Reduction is Minimum Necessary to Achieve State GHG and Petroleum Goals

AB32 requires reductions from all sectors. To meet the AB32 goals of returning emissions to 1990 levels by 2020, all sectors will have to make substantial reductions. A 10 percent reduction in the carbon intensity of transportation fuels will contribute 13.4 million metric tons of CO_2 reductions, over half of the 24 million metric tons of CO_2 reductions needed to return passenger vehicles and light trucks to 1990 levels.[13]

A 10 percent reduction will also assist with the following state goals: Replace 20 percent of on-road energy use with non-petroleum fuels by 2020. A low carbon fuel standard provides a route for compliance with the CEC *2003 Integrated Energy Policy Report* goal of 20 percent non-petroleum fuel use by 2020 while reducing greenhouse gas emissions.[14]

On average, low carbon fuels employed to meet the LCFS will generate 50 percent lower greenhouse gas emissions than gasoline.[15] Therefore, a requirement of 10 percent reduction would result in replacing 20 percent of petroleum use with low-carbon fuels. Governor's Bioenergy Action Plan goals. Governor's Schwarzenegger's *Bioenergy Action Plan* established targets for the use and production of biomass products for electricity and transportation fuels.[16]

The Plan's target is to produce a minimum of 40 percent of bio-fuels within California by 2020. Establishing a large and growing market in California for low carbon fuels is essential to achieving this goal, which would be equivalent to 1.0 to 1.9 billion gallons of in-state ethanol production. California has the potential to produce 3 billion gallons by 2020 primarily by using agricultural and municipal waste material.[17]

10 Percent Reduction Goal is Achievable

To achieve a 10 percent reduction in carbon intensity, fuel providers will need to reduce the carbon intensity associated with their fuels from about 97.4 kg of CO2-eq/MMBTU to 87.7 kg/MMBTU. Table 2 shows *one* possible mix of strategies that could be used to achieve this goal by 2020. While at this time we believe the most likely strategies are E10, E85, switching to cellulosic ethanol, plug-in hybrids, and hydrogen fuel cells, markets will determine whether that mix or others (including options such as biobutanol or biocrude) will be employed to meet the standard.

Table 2. Possible Compliance Scenarios to Meet 10 Percent Reduction Target in 2020

Scenario Number-->	**1**	**2**	**3**
Total Petroleum Displaced by Low-Carbon Fuels (B gal)	3.0	3.1	3.2
Low-Carbon Fuels			
Total Ethanol Demand (B gal)	2.7	3.8	4.7
Number of FFVs (millions)	3.0	6.0	8.5
Number of PHEVs (millions)	4.1	1.7	0.0
FCVs (millions)	0.5	0.5	0.2
Source: Natural Resources Defense Council estimates[18]			

Benefits of a Low Carbon Fuel Standard

Adoption of a Low Carbon Fuel Standard will substantially reduce global warming pollution, cut petroleum dependency and create a sustainable and growing market for cleaner fuels. Based on the mix of strategies shown in Table 3, we estimate that a fuel standard requiring an initial reduction of 10 percent in the greenhouse gas impacts of passenger vehicle fuels by 2020 will:

- Cut global warming pollution from the passenger vehicle fleet by 10 percent, equivalent to removing 3 million cars from the road.
- Displace 20 percent of on-road gasoline consumption with low-carbon fuels, reducing consumption by up to 3.2 billion gallons of gasoline per year, equivalent to the output of 2.5 average-sized California refineries.[19]
- Expand the size of the current renewable fuels market in California (already the largest in the nation) by 3 to 5 times. Instead of today's corn, over half of the ethanol is likely to be made from extremely low-carbon, cellulosic feedstocks such as agricultural waste and switchgrass.[20]
- Place on California's roads more than 7 million alternative fuel and hybrid vehicles, approximately 20 times the number of such vehicles on California's roads today.

In addition, the LCFS can be expected to:

- Grow California's clean energy industry. California is well poised to lead the nation in the emerging "cleantech" business sector.[21]
- Help protect Western lands and discourage unclean energy developments. In the absence of a transition to clean fuels, industry is expected to develop highly polluting domestic resources, such as fuel from coal-to-liquids that doubles carbon pollution per gallon and other "unconventional" oil resources such as tar sands and oil shale, that are not only much worse for the climate (as much as twice as polluting as conventional gasoline) but also destroy wilderness areas and use scarce water resources.[22]
- Reduce California's dependence on imported oil and keep more money in the state. According to the CEC, if no steps are taken to diversify our fuel sources, by 2020 about half of our oil will be imported from overseas.[23] A low carbon fuel standard, coupled with other policies to encourage clean fuel production, will keep a significant and growing fraction of that money in the state.
- Reduce risk to the state's economy. By reducing the sensitivity of its economy to oil price uncertainty and shocks resulting from refinery outages, cartel actions or disruptions in world oil supplies, California will reduce the risk to sales, wages and jobs. Figure 4 illustrates recent volatility of, and trends in, gasoline prices.

Implementation Process

The Low Carbon Fuel Standard will move from a framework analysis to be conducted during summer 2007 to implementation by the end of 2008.

The LCFS will be implemented after the completion of a detailed report and regulatory proceedings. The signing of the Executive Order will initiate this process. The following is a brief description of how the LCFS will be implemented.

Analytical Report. The University of California will undertake a study, in partnership with the California Energy Commission (CEC) and the Air Resources Board (CARB), to develop the framework for the Low Carbon Fuel Standard (UC Study). Once this study is complete, it will be introduced into the California Energy Commission's current proceeding to develop a state strategy to increase the amount of alternative fuels in California pursuant to Assembly Bill (AB)1007 (Chapter 371, Statutes of 2005).

Adopt the Low Carbon Fuel Standard. The CEC will incorporate the UC Study into the CEC's AB 1007 Report. The CEC will conduct public hearings on the AB 1007 Report and after deliberation, will propose a compliance schedule for the Low Carbon Fuels Standard as part of the AB 1007 Report. The Governor's Executive Order asks for the AB 1007 report to be finalized by June 30, 2007.

Implement the Standard. Upon CEC adoption of the AB 1007 Report, the CARB will initiate a regulatory proceeding which will establish and implement the Low Carbon Fuel Standard. In advance of this and by June 30, 2007, the CARB will determine if a Low Carbon Fuel Standard can be developed as a discrete early action measure pursuant to the Global Warming Solutions Act, and if so, will consider the adoption of a Low Carbon Fuel Standard on the list of early action measures. Also, because electric and natural gas utilities represent a source of transportation fuels, the Governor's Executive Order requests the Public Utilities Commission, in its current implementation of the GHG emissions cap adopted by Decision 06-02-032, to examine and address how investor-owned utilities can contribute to reductions in GHGs in the transportation sector.

1 Essentially producers, importers, refiners and blenders

2 Sometimes called "full fuel cycle," "well-to-wheels" or in the case of biofuels "field-to-wheels"

3 The CEC's 2003 IEPR stated a goal of 20 percent alternative fuel use by 2020 (California Energy Commission, 2003 *Integrated Energy Policy Report*, December 2003, 100-03-019.)

4 Bioenergy Interagency Working Group, Bioenergy Action Plan for California, California Energy Commission, July 2006. CEC 600-2006-010

5 A recent study by Environmental Entrepreneurs [Creating Cleantech Clusters: 2006 Update, www.e2.org] reported that, "Cleantech investors overwhelmingly agree that public policy can be an important driver for new job and investment growth: 91% of "cleantech" venture capitalists surveyed say that pro-environmental public policy can be a driver in bringing new business and investment to a state and 79% of cleantech venture capitalists surveyed say that current public policies (regulations, programs and

incentives) are a prominent factor in their investment decisions."

[6] For example, refiners seeking the lowest-cost and most consumer-responsive methods by which to meet the standard will be able to choose among competing bio-fuel blends, credits from competing utilities providing clean electrons to the electric car marketplace, credits from clean hydrogen and more, and base their decisions on market and cost factors no different than the factors they employ in the ordinary course of business. Similarly, the new standard will expand investment in, and competition between, the infrastructures through which alternative fuels can be delivered to customers. Moreover, the standard will accomplish this without significant taxpayer investment and without government picking which alternative fuel or fuels will be the winners.

[7] Unlike the concept of Renewable Fuel Standards, the LCFS measures greenhouse gas impact over full fuel cycles, allows fuels other than ethanol to be used for compliance, and will discourage the development of high-carbon unconventional oil. In addition, there is great variation in the GHG reduction from ethanol depending on feedstock (i.e., corn, sugar crops, or woody plant material known as "cellulosic" feedstocks), cultivation methods (i.e., low-till, other) and processing (i.e., coal, natural gas, methane, other). E.g., a corn ethanol plant using coal would actually increase GHGs slightly (see Figure 5 below).

[8] It is likely that vehicles with inherently greater efficiency, such as battery electric vehicles and hydrogen fuel cells, will need an adjustment factor to their emissions factors in order to accurately reflect their GHG benefits. For example, strictly in terms of kilograms of CO2-equivalent per BTU consumed basis, electricity is responsible for about 1.8 times more GHG emissions. However, when the greater inherent efficiency of electric drive is considered ,the actual benefits of GHG displacement is about a two-thirds reduction.

[9] Sometimes referred to as "well to wheel," "full fuel cycle", or in the case of biofuels, "field to wheel" basis. To avoid double-counting, GHG emissions from the vehicles themselves would not be included since they are already regulated under the AB1493 vehicle standards. Likewise, emission reductions credited to the LCFS will not be eligible for credit towards other AB32 regulations, if any.

[10] Credit life to be determined

[11] See for example: NESCAUM, "Environmental Technology and Technology Innovation: Controlling Mercury Emissions from Coal-Fired Boilers," Northeast States for Coordinated Air Use Management, September 2000; Anderson and Sherwood, "Comparison of EPA and Other Estimates of Mobile Source Rule Costs to Actual Price Changes," presented at the SAE Government Industry Meeting, DC, May 14, 2002, SAE 2002-01-1980; Harrington et al., "On the Accuracy of Regulatory Estimates," Resources for the Future, January 1999; and NESCAUM 2000. Cackette, "The Cost of Emission Controls, Motor Vehicles and Fuels: Two Case Studies," presentation at MIT, 1998

[12] Ellerman, A.D., P.L. Joskow, et al., Markets for Clean Air: the U.S. Acid Rain Program, Cambridge University Press, 2000

[13] Based on the *Climate Action Team Report to Governor Schwarzenegger and the Legislature (http://www.climatechange.ca.gov/climate_action_team/index.html)*. The remaining reductions in 2020 are projected to come from AB 1493 vehicle pollution standards and from better transportation planning reducing the amount of miles driven. For these estimates, we use the Climate Action Team GHG

inventory convention of vehicle end-use only.

14 For full report, go to http://www.energy.ca.gov/2003_energypolicy/index.html.

15 For ethanol, this can be achieved through a mixture of 54 percent corn and 46 percent lignocellulosic ethanol. Electricity can reduce GHGs by 67 percent, according to analysis by CARB in support of the AB 1493 standards.

16 For full report, see http://www.energy.ca.gov/bioenergy_action_plan/ .

17 See Navigant Consulting, *Recommendations for a Bioenergy Action Plan for California*, draft consultant report prepared for the Bioenergy Interagency Working Group, March 2006, CEC-600-2006-004-D.

18 Key assumptions for these scenarios:

- Baseline gasoline contains 5.7 percent ethanol derived from corn.
- All fuel providers increase the blending of ethanol to 10 percent by volume from today's 5.7 percent. The remainder of the ethanol is sold as E85 for use in flex fuel vehicles (FFVs.)
- On average, the ethanol mix used reduces GHGs by 50 percent compared to gasoline. This can be achieved through 50/50 mixture of corn ethanol at about 20 percent reduction and a cellulosic ethanol at 80 percent reduction.
- Plug-in hybrids (PHEVs) use electricity for 50 percent of their driving and using electricity reduces GHG emissions by 67 percent compared to gasoline.
- Hydrogen fuel cells reduce GHG emissions by at least 30 percent compared to gasoline, based on the goals of California Hydrogen Highway Network.

19 To develop this estimate, we developed several scenarios of low-carbon fuel mix that could be used to meet the standard. The low-carbon fuels considered were: ethanol derived from corn, ethanol derived from lignocellulosic materials (or simply "cellulosic"), electricity and hydrogen. The primary vehicle use strategies were to increase blending to 10 percent by volume, use ethanol as E85 (85 percent ethanol, 15 percent gasoline), plug-in electric vehicles, and hydrogen fuel cell vehicles.

20 California currently uses 5.7 percent ethanol by volume in its gasoline, about 900 million gallons per year, almost all of which is made from corn. Corn ethanol reduces GHG by about 18 percent compared to gasoline; in comparison, using "lignocellulosic" materials (including agricultural and municipal solid waste, and specially grown energy crops such as switchgrass) reduces GHG by 88 percent. See Farrell et al., "Ethanol Can Contribute to Energy and Environmental Goals," *Science*, January 27, 2006.

21 See Calstart report, *California's Clean Vehicle Industry, How the Drive to Reduce Automotive Global Warming Pollution Can Benefit the California Economy*, 2004, and Environmental Entrepreneurs, *Creating the California Cleantech Cluster, How Innovation and Investment Can Promote Job Growth and a Healthy Environment,* September 2004.

22 See Farrel and Brandt, "Risk of Oil Transitions," Environmental Research Letters, October 30, 2006. The LCFS will provide a powerful market signal, from one of the largest markets for gasoline in the world, to help slow and eventually stop the development of these unclean fuels. In this regard, a low carbon fuel standard for transportation fuels will perform a role similar to the groundbreaking SB1368 law, signed by the Governor in 2006, to encourage clean power plants and discourage investments in unclean coal power plants in the West.

[23] According to the CEC (http://energy.ca.gov/oil/statistics/crude_oil_receipts.html), foreign imports made up about 40 percent of petroleum use in 2005. Assuming CA production declines by 2 percent per year and Alaska can only make up 1 percent of that, foreign imports would be close to 55 percent in 2020. Fuel use, based on LDV data, is expected to grow 12 percent in the same time. Therefore, 55 percent of ~728 million barrels per year would be 400 million barrels per year and conservatively at $45 per barrel, this would be about $18 billion per year.

January 8, 2007

David Crane and Brian Prusnek

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