Implications for Crude Oil Carbon Intensity Differentiation under the LCFS

California Air Resources Board
LCFS Periodic Review Advisory Panel
1 July 2011

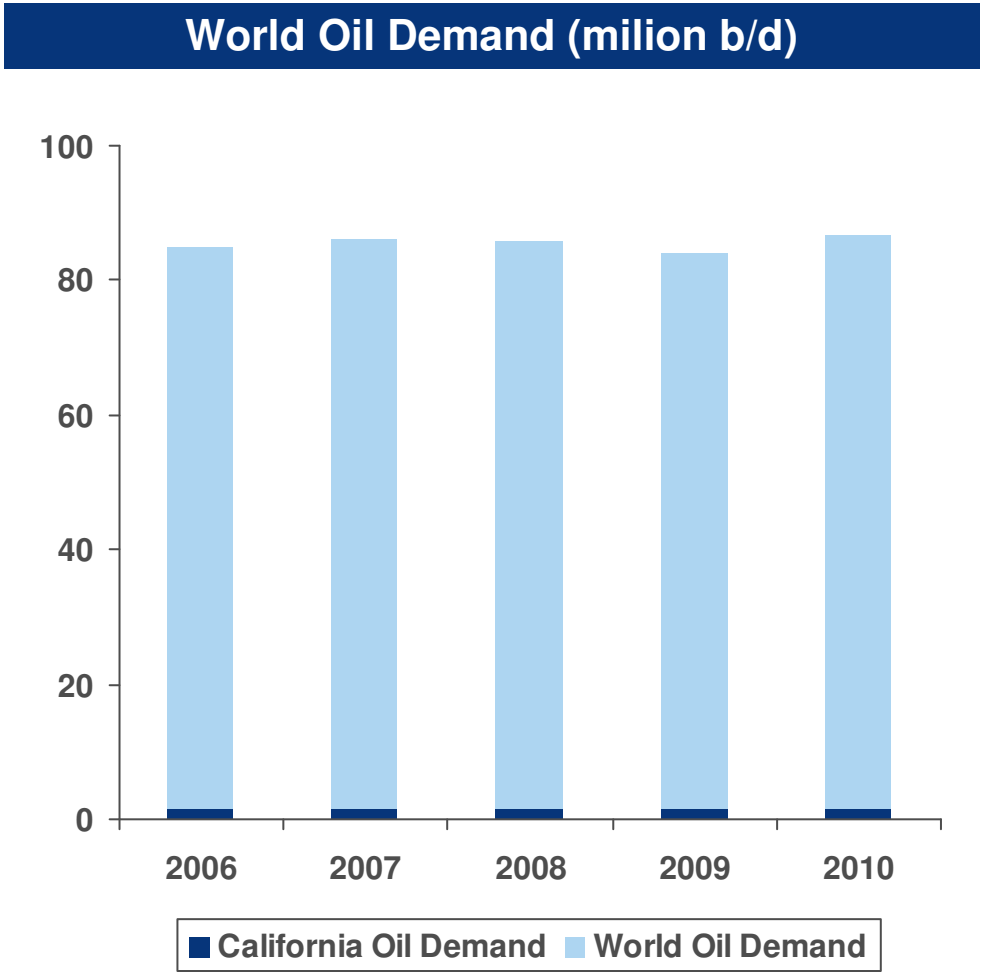
Wood Mackenzie
downstream consulting

Summary Findings

- **The global crude oil market is large with Californian accounting for less than 2%**
  - High carbon crudes rejected by one market likely could supply other markets where no carbon cost exists – carbon leakage
  - Crude feedstocks change on a regular basis and California's changed significantly since 2006
- **Californian refineries are generally complex with a design to process heavy/medium crudes**
  - The LCFS / HCICO burden restricts crude feedstocks
  - Creates the potential to lower operational refinery efficiency
- **Crude oil markets are global and producers have alternatives to investment in GHG abatement, with unintended consequences, such as**
  - Increase in GHG emissions from crude oil "shuffling" as tankers passing each other with near-by "high intensity" crudes oils displaced by long-haul "low intensity"
- **Under the LCFS we expect refiners to prefer processing 2006 baseline crudes**
  - Results in a more restricted crude feedstock
  - Llikely to increase security of supply concerns as some 2006 baseline production declines
- **Cost of crude oil differentiation may…**
  - Not be borne by crude oil producers
  - Find its way into petroleum product consumer prices

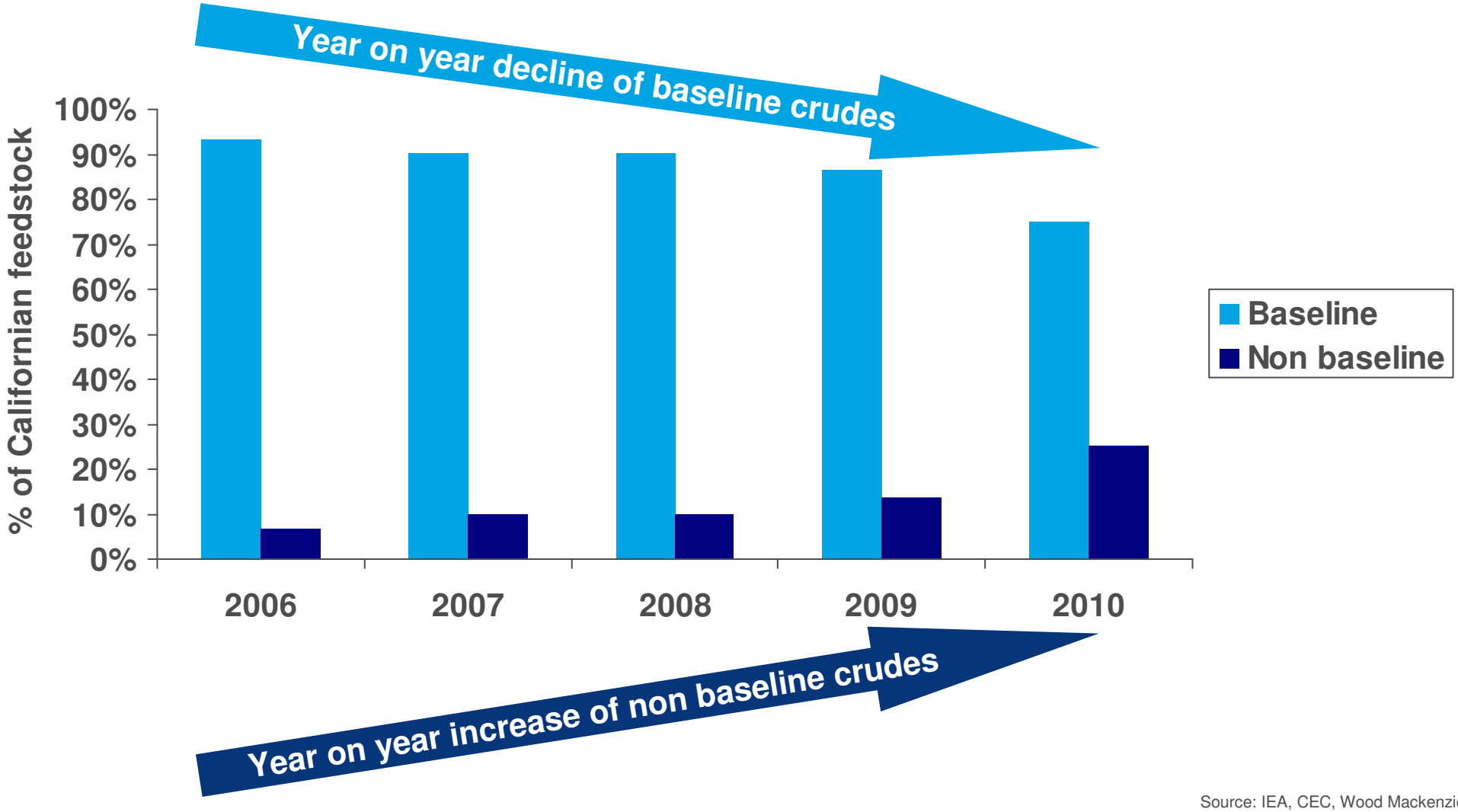
Global crude oil market is large and high carbon crudes rejected by one market are likely to supply markets where no carbon cost exists

- Total world demand for crude oil is approximately 85 million barrels a day
- Californian crude oil demand represents less than 2% of world demand
- High carbon crude oils, which could supply California but for the LCFS, will still be produced and instead supply markets where no such carbon policy exists



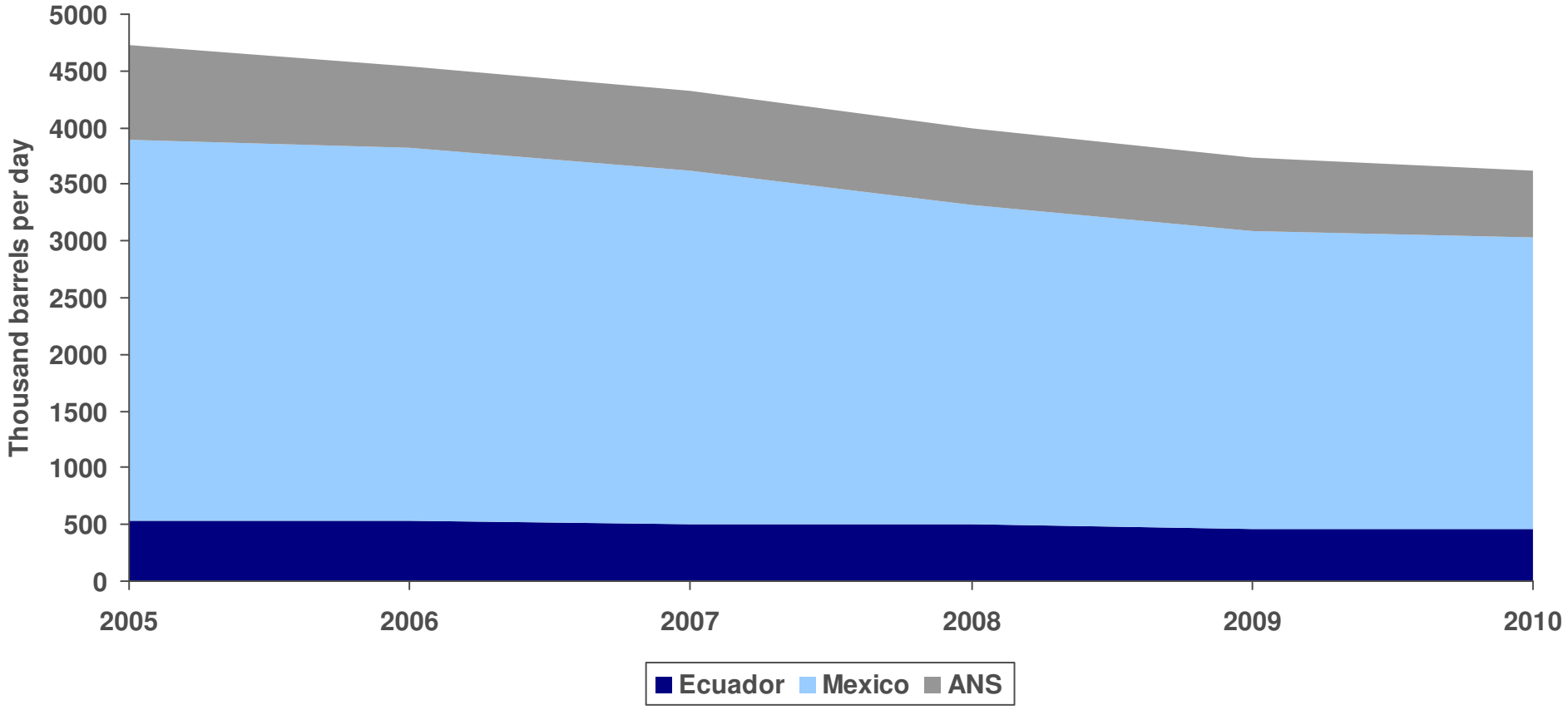
Source: Wood Mackenzie

Californian refineries increasingly are processing non-2006 baseline crudes



Source: IEA, CEC, Wood Mackenzie

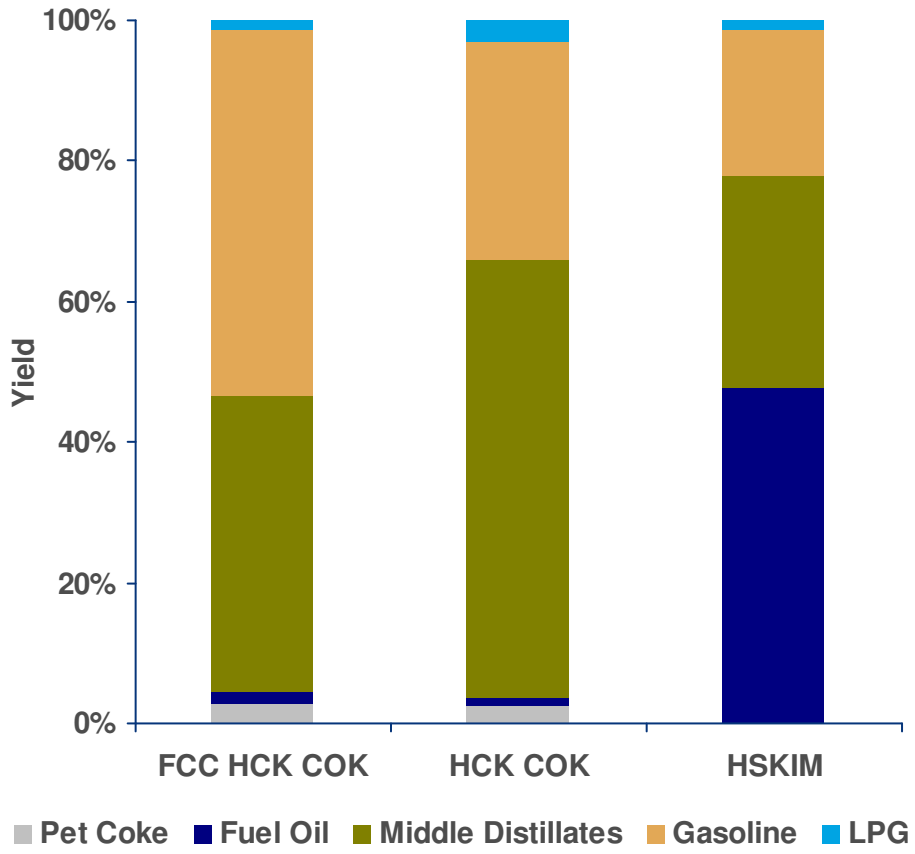
Declining production of some 2006 baseline crudes is a challenge



Many Californian refineries are designed to run heavy crude

- Complex refineries like some in California process heavy crudes which typically sell at a discount to lighter crudes due to their high fuel oil yield
- PADD V processes ~60% heavy, 40% medium
- Complex refineries upgrade low value fuel oil into higher value lighter oil products via their complex units such as cokers
- Running a light crude in complex refineries would be inefficient, depriving complex units of their feedstock and negatively affecting refining margins
- For Californian refiners to obtain value from their complex refining capacity they need to maintain a heavy / medium crude slate
- Potentially limits flexibility of refiners to replace high carbon intensity with lower carbon intensity crudes

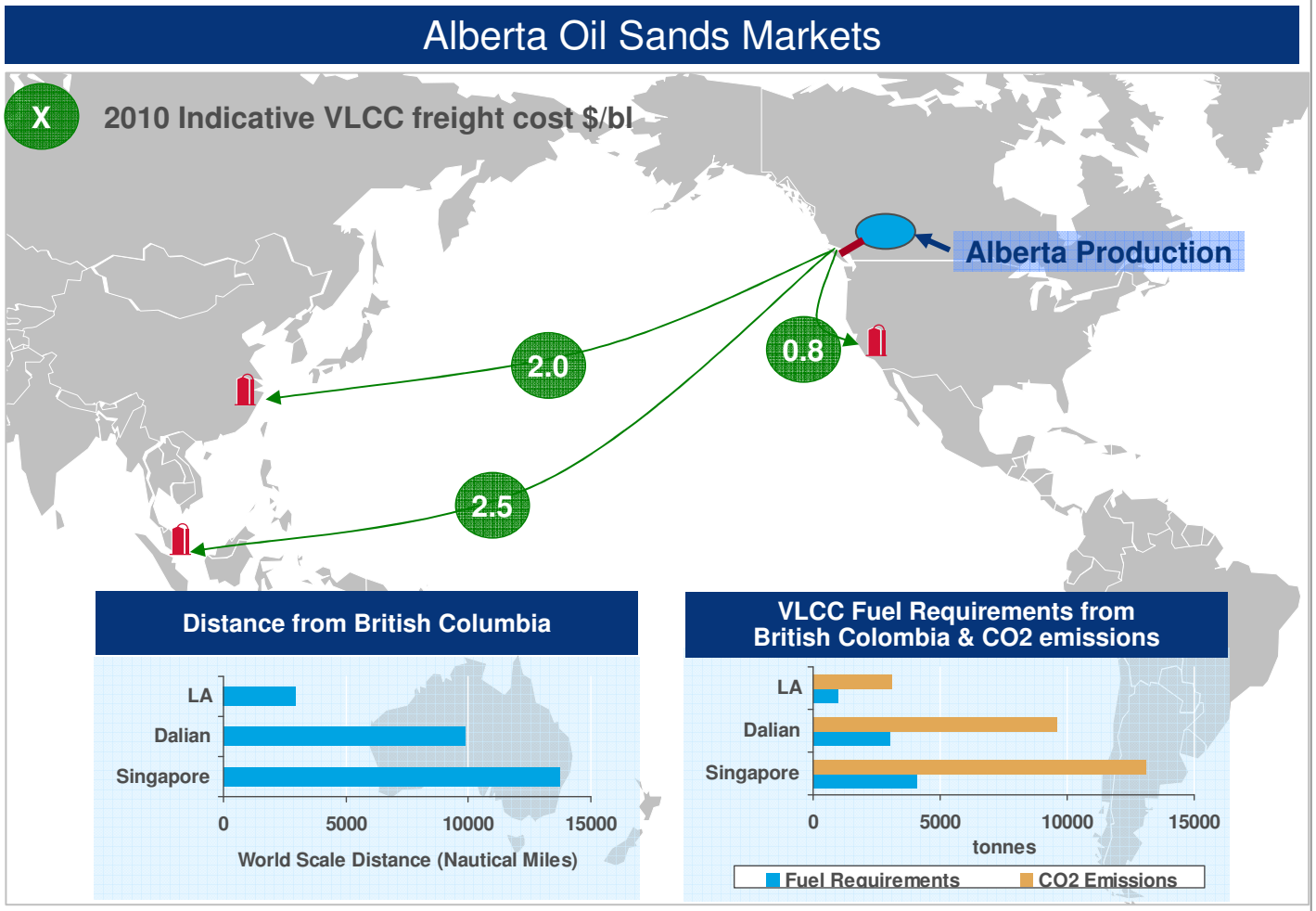
Typical Refinery Yields (~22 API Crude)



Source: Petroplan

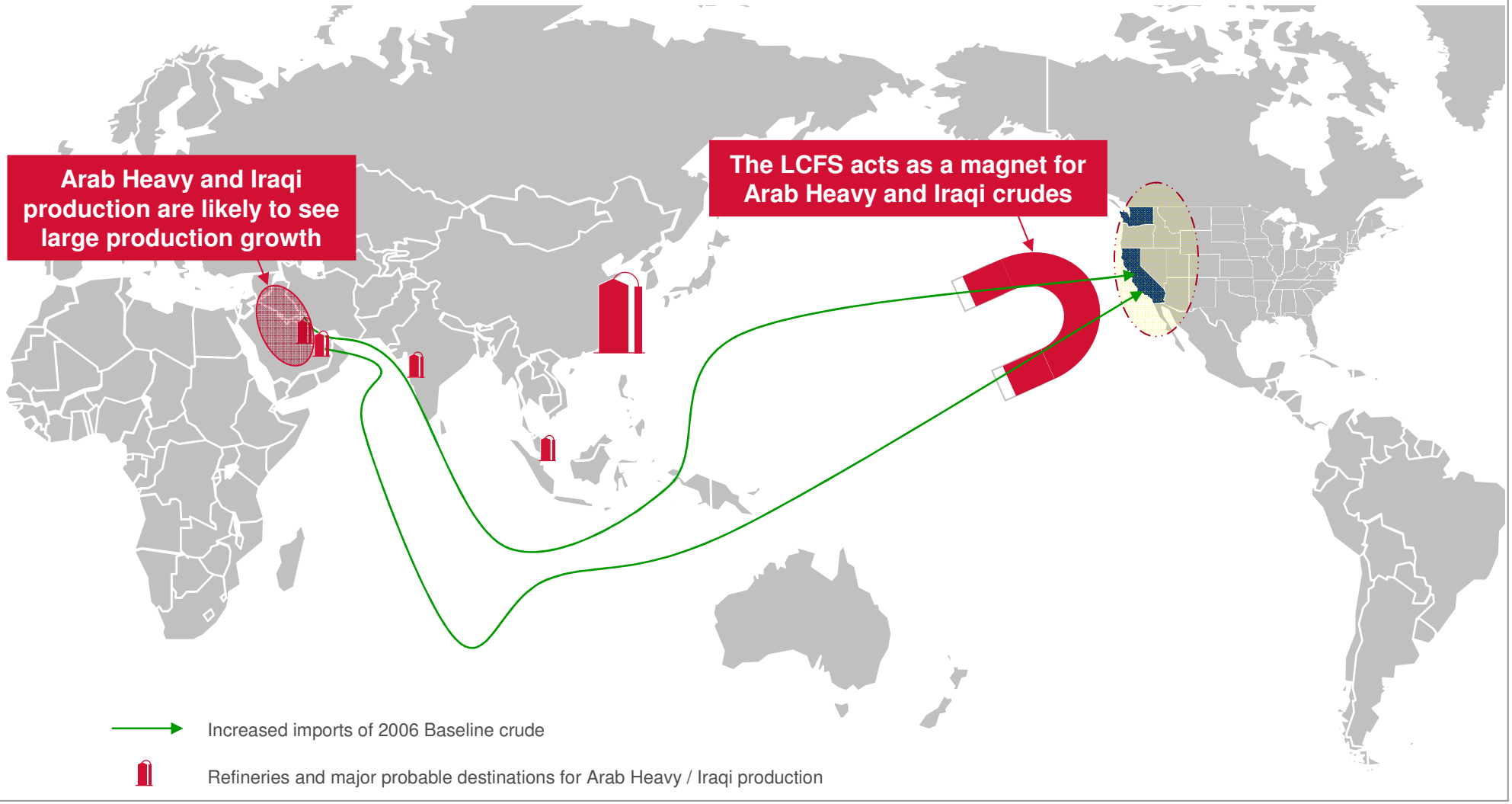
HCICO production from Canada is likely to be diverted to Asia, raising the carbon emissions from freight

- Carbon costs might push HCICO Canadian crudes out of the USWC market and towards markets with growing demand and no carbon penalty, such as China
- A VLCC sailing to China creates approximately triple the carbon emissions as sailing to Los Angeles due to greater freight distance

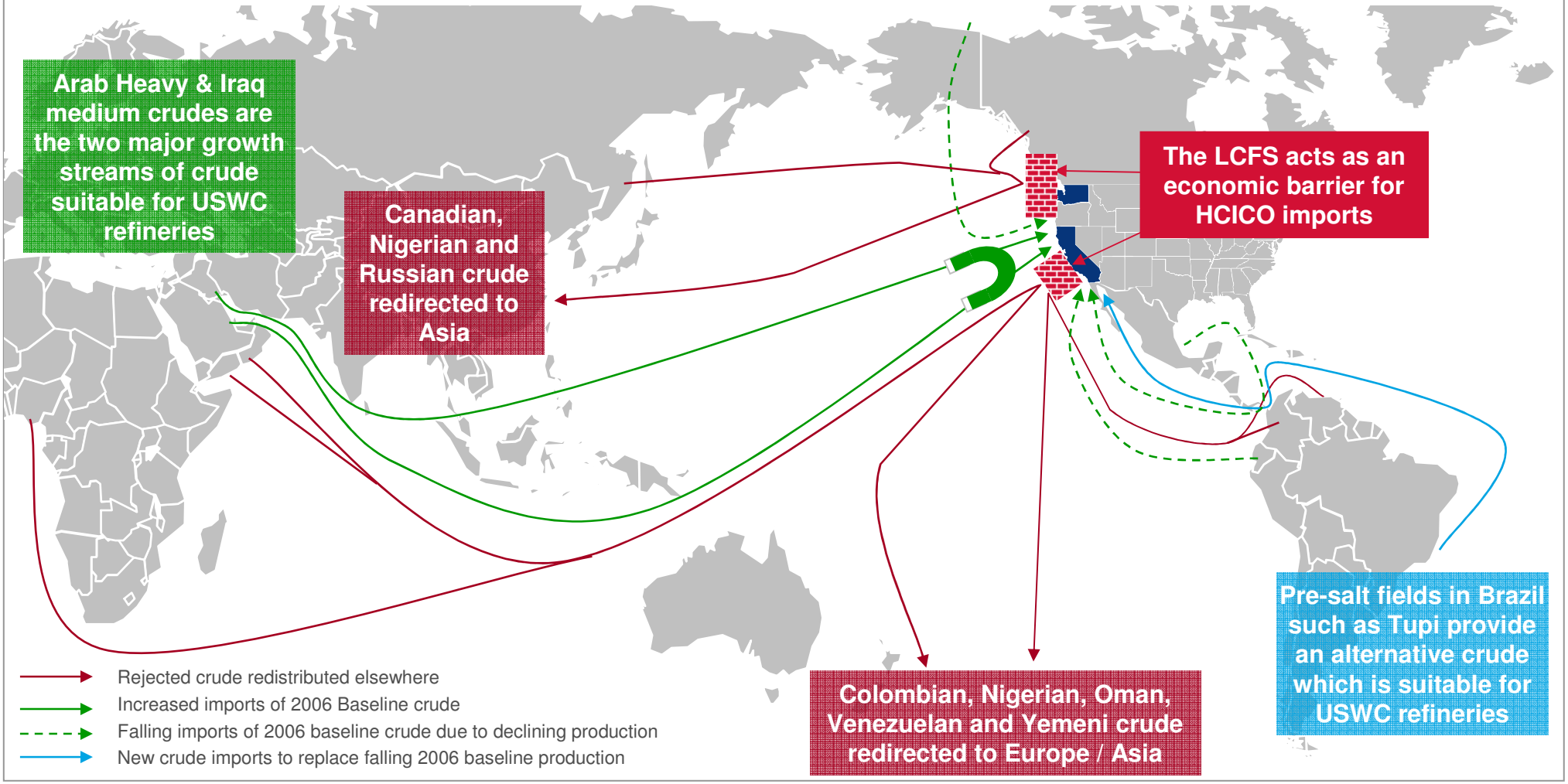


Source: Wood Mackenzie, Clarksons, Worldscale, National Energy Foundation

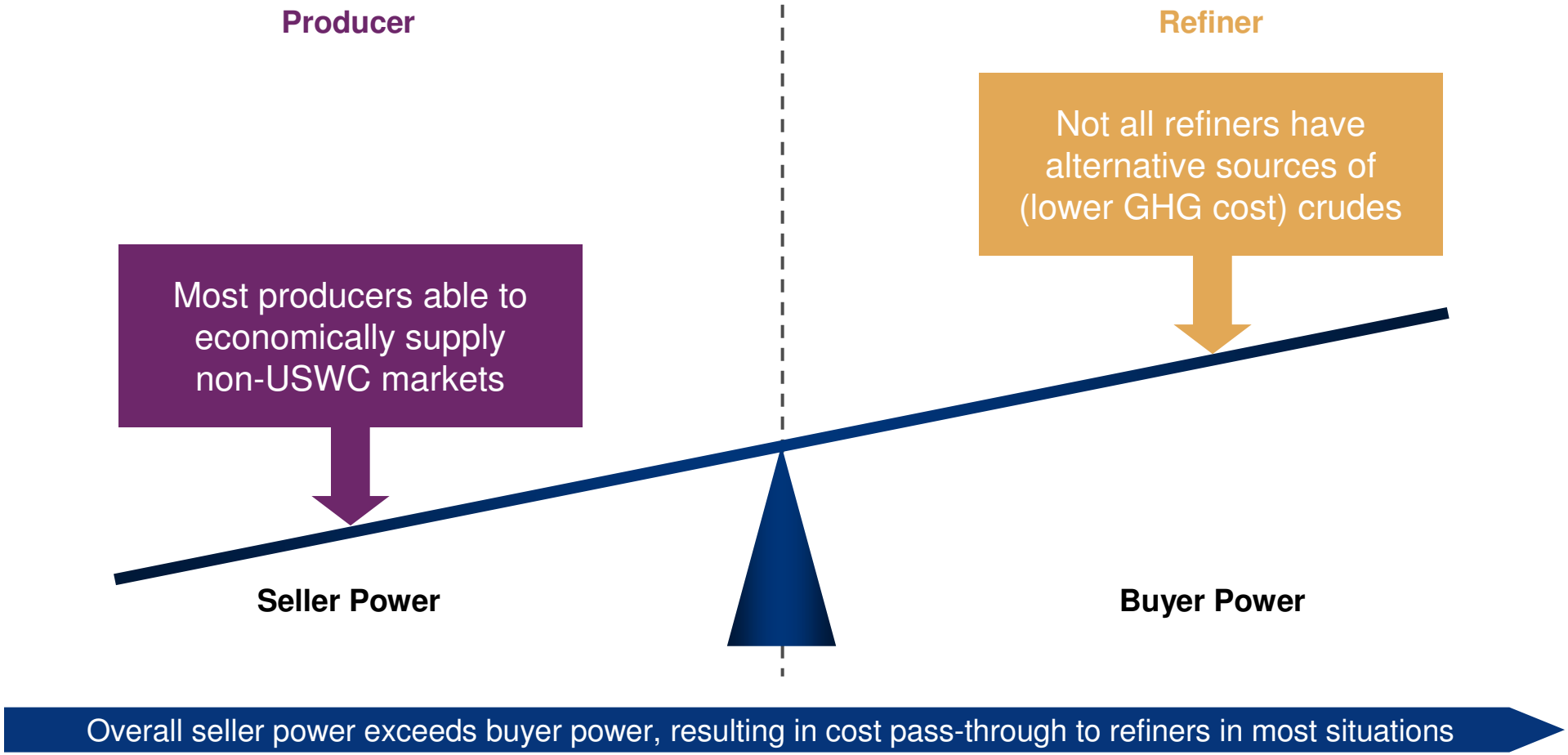
Demand for Middle Eastern 2006 baseline crude could rise, drawing crude from other markets and increasing GHG freight emissions



LCFS is likely to push regional HCICOs into Asia and increasingly draw in 2006 baseline crudes from the Middle East, increasing GHG freight emissions



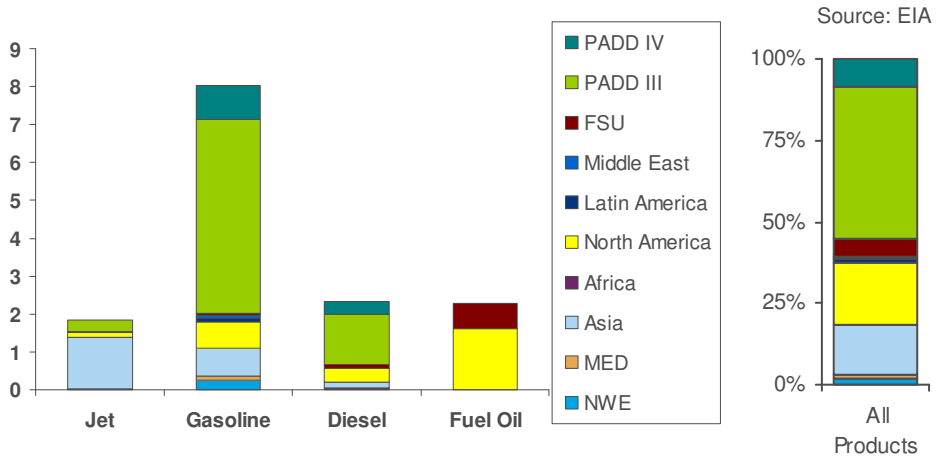
Most crude suppliers to PADD V markets have other supply options so producers potentially are unlikely to pay all of the crude GHG burden



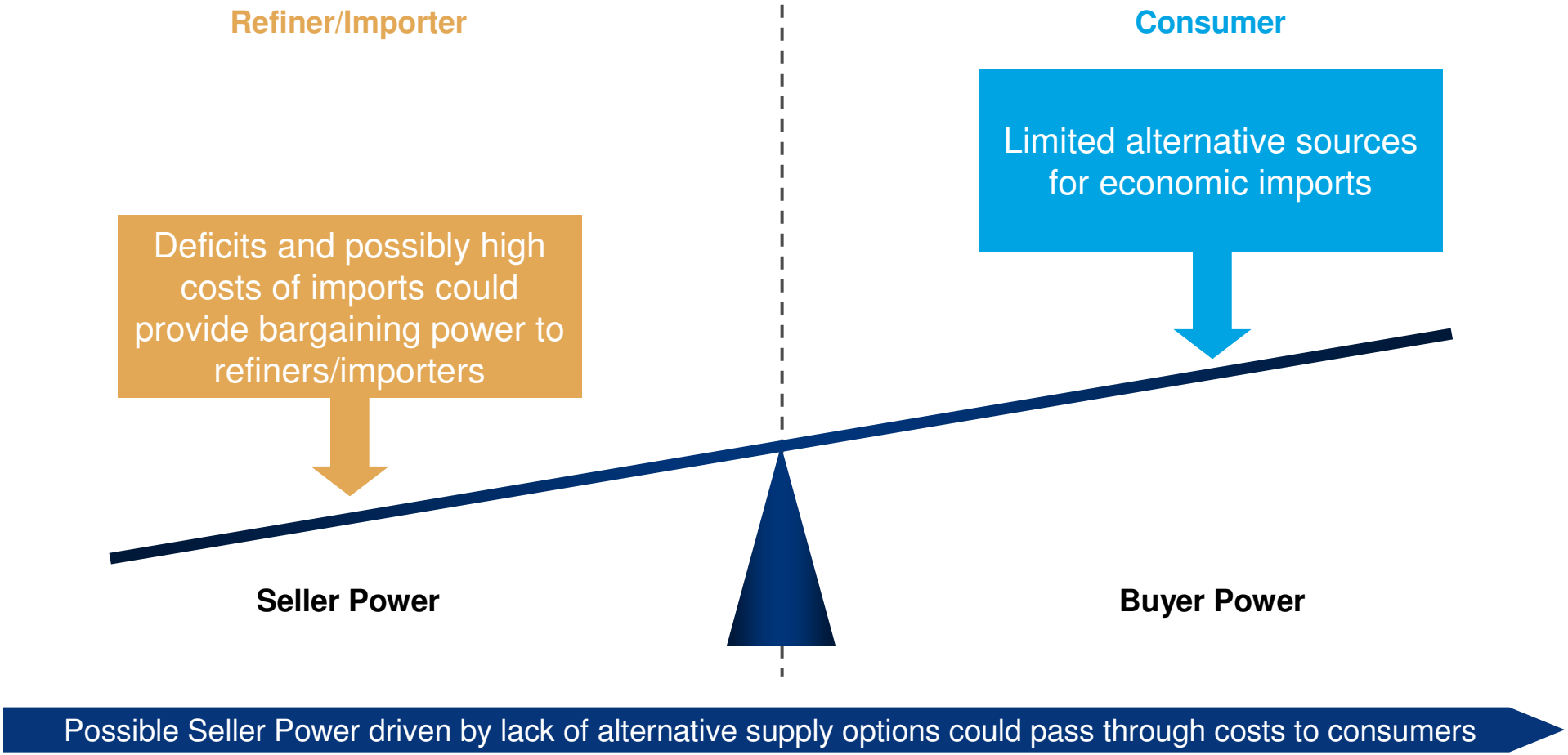
Carbon burden on California refineries could threaten security of supply

- **PADD V is a product deficit market**
  - CARB fuels are difficult to produce because of its complex specifications
  - Only a limited number of refiners outside PADD V can make CARB-compliant fuels
  - PADD V is geographically isolated; fuel supply from outside the region is difficult and costly
  - Asia has large and growing deficits for oil products, which further limits both crude and product availability for California
- **Assuming California demand is constant a carbon cost could**
  - Potentially reduce refinery margins leading to…
  - Potentially reduced refinery runs leading to…
  - Potentially creating a need for more imports…
  - Potentially resulting in a higher product price environment if incremental product imports come form farther distances

PADD V oil product imports 2009 (Mt)



Consumer prices in PADD V markets possibly may rise from a CO2 burden



Conclusions

- Cost of crude oil differentiation could find its way into petroleum product consumer prices
- Crude oil differentiation likely to increase security of supply concerns as some 2006 baseline production declines
- Crude oil markets are global so high carbon crudes rejected by one market are likely to supply markets where no carbon cost exists
- Crude oil "shuffling" as tankers passing each other with near-by "high intensity" crudes oils displaced by long-haul "low intensity" could increase in GHG emissions

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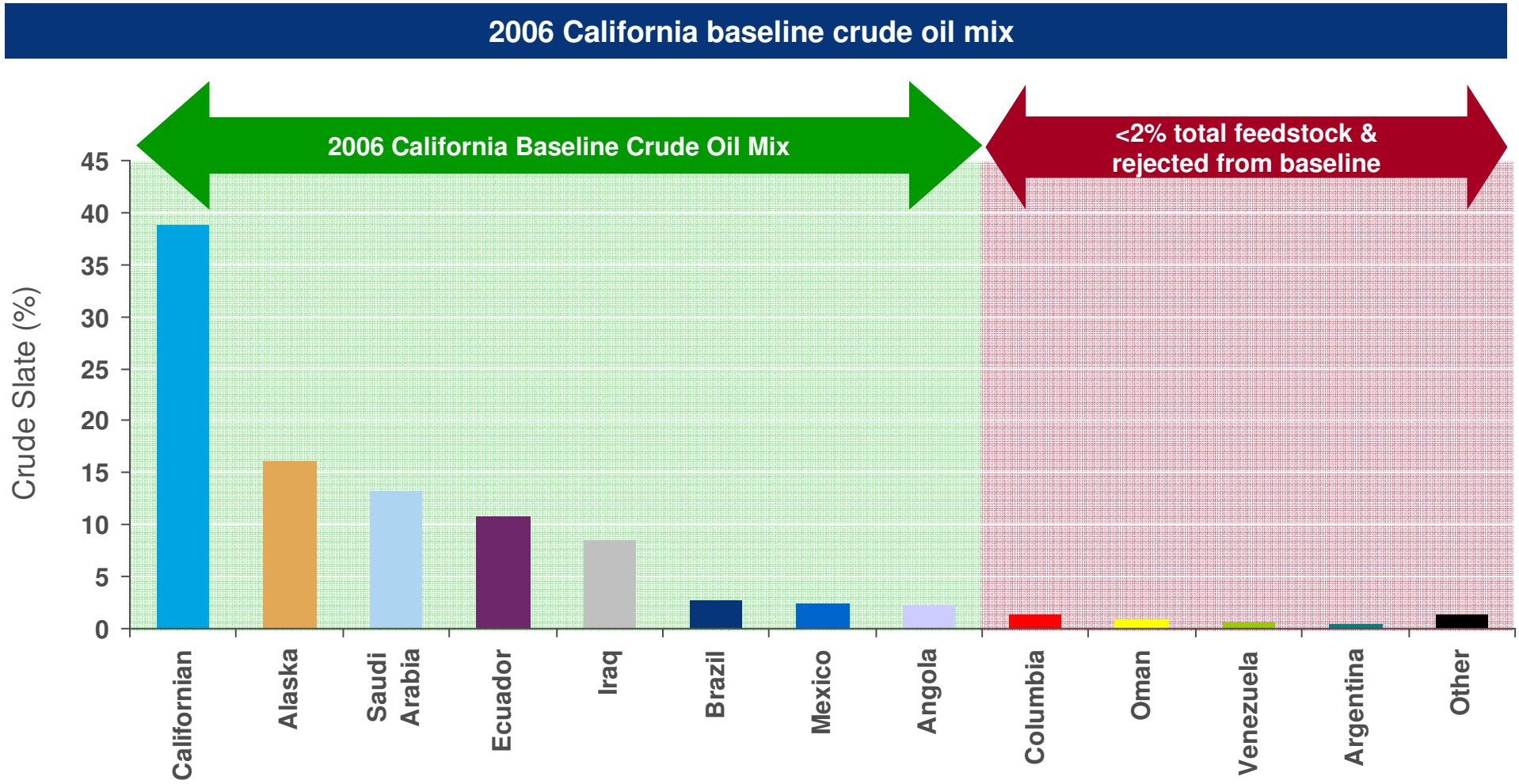
Appendix

Californian ARB regulations add a GHG cost by reviewing crude characteristics

- **On April 23, 2009 the California Air Resources Board (ARB/Board) approved the Low Carbon Fuel Standard (LCFS) regulation**
  - Carbon intensity of crude oil sources under the LCFS is split into Non-High Carbon Intensity Crude Oil (Non-HCICO) and High Carbon Intensity Crude Oil (HCICO)

	Non-HCICO	HCICO
What are they	• Crudes which constituted 2%+ of Californian feedstock in 2006 and are thus included in the 2006 California baseline crude oil mix, or • Crude not included in the California baseline but which has a total less than 15g CO2e/MJ based upon tests of upstream carbon emissions associated to flaring and extraction methods such as thermally enhanced oil recovery	• Crudes not included in the 2006 California baseline crude oil mix, and which • Fail the test on production & transport carbon emissions
Carbon intensity	• Fuels derived from these crudes will be assigned the average carbon intensity value for CARBOB, gasoline or diesel from a lookup table of weighted averages based on the 2006 California baseline crude mix • The carbon intensity considers the production and transport carbon intensity	• Fuels derived from these crudes will be assigned a carbon intensity value for CARBOB, gasoline or diesel specific to the crude processed • A default carbon intensity of 20g/MJ is one proposed option drafted by ARB
Carbon price	• Yet to be determined	• Yet to be determined

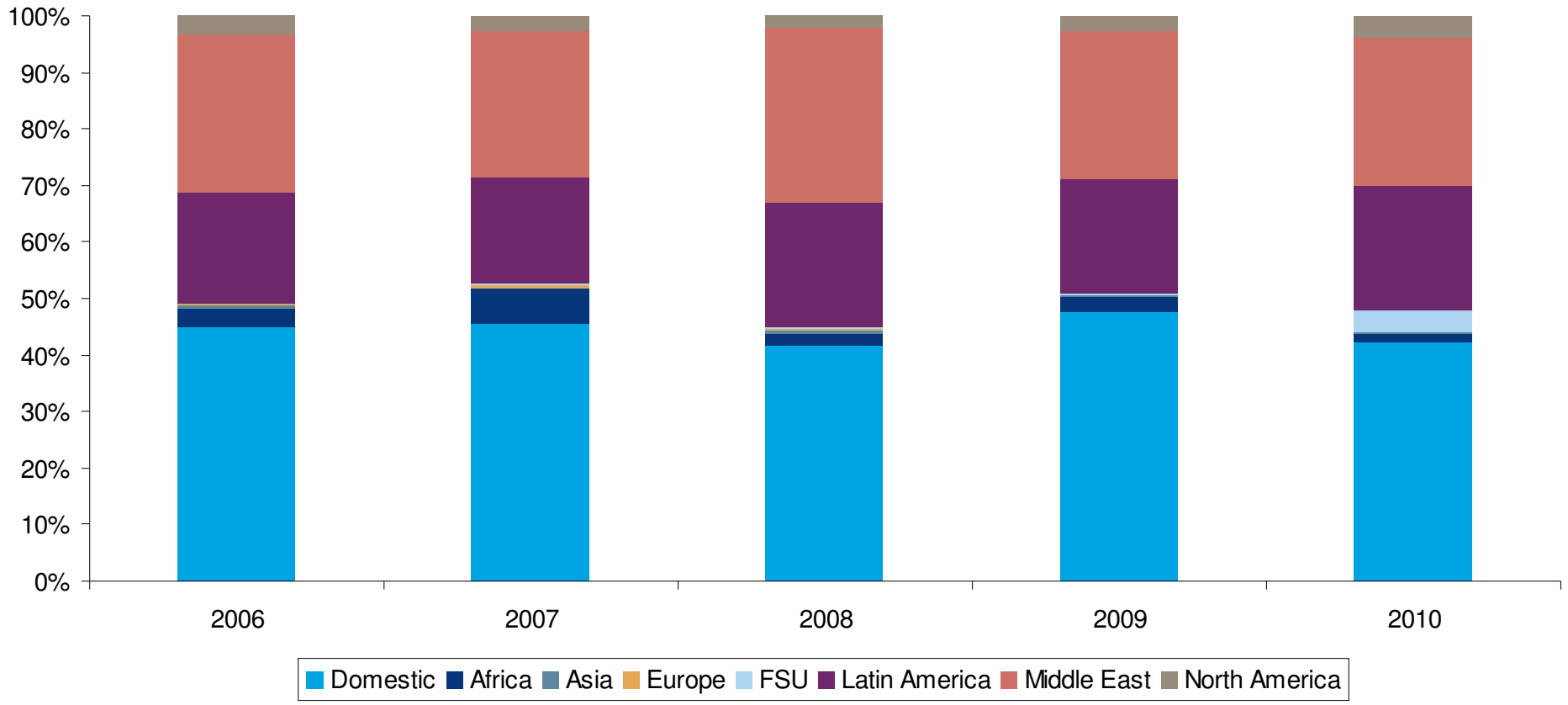
The California baseline crude oil mix was set on 2006 refinery feedstock



Source: CEC

But feedstock sources have changed & new crudes introduced since 2006

Californian Crude Feedstock Sources



6 new countries supplied crude to California each year (compared to 2006)

Source: IEA, CEC, Wood Mackenzie

Crude oil markets are global and producers have alternatives to investment in GHG abatement – many with unintended consequences

- **Redistribution of a producers' crude oil sales to other markets**

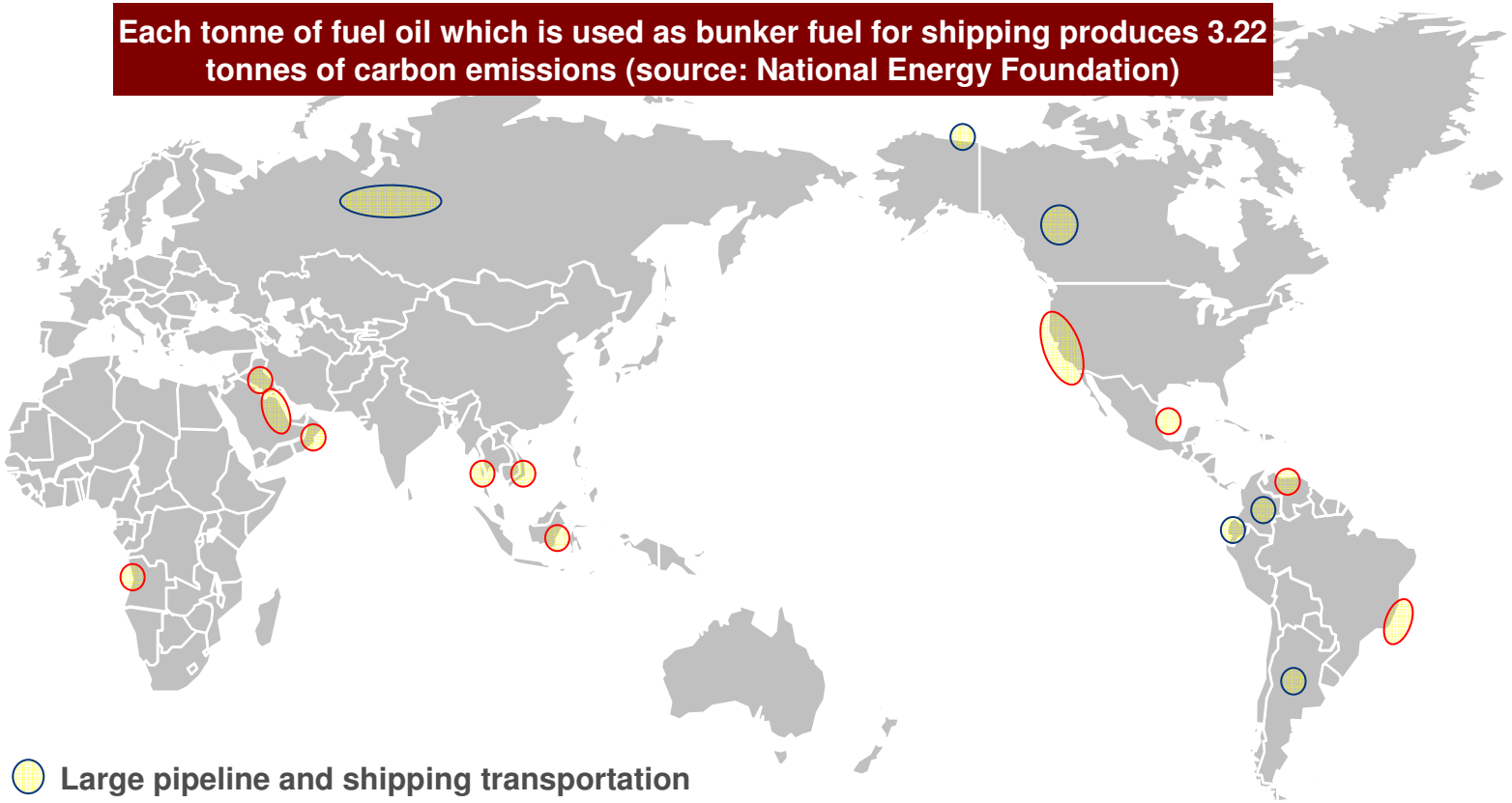
- **Increase in global crude freight, resulting in increased GHG emissions from crude oil tankers**
  - For Canadian producers, this could equate to diversion of regional supply into the US to more distant possibly Asian markets reached via increased seaborne freight
  - Reduced security of supply if regionally produced high GHG crudes are displaced by lower GHG imports

- **Increased crude supply cost to USWC markets could pressure USWC refinery margins relative to other markets potentially resulting in:**
  - Reduced activity levels at USWC refineries
  - Reduced security of supply if USWC production potentially is replaced with product imports

Freight CO2 emissions are important due to the distance crude travels

Principle Sources of USWC Refinery Crude Oils

Each tonne of fuel oil which is used as bunker fuel for shipping produces 3.22 tonnes of carbon emissions (source: National Energy Foundation)



Large pipeline and shipping transportation

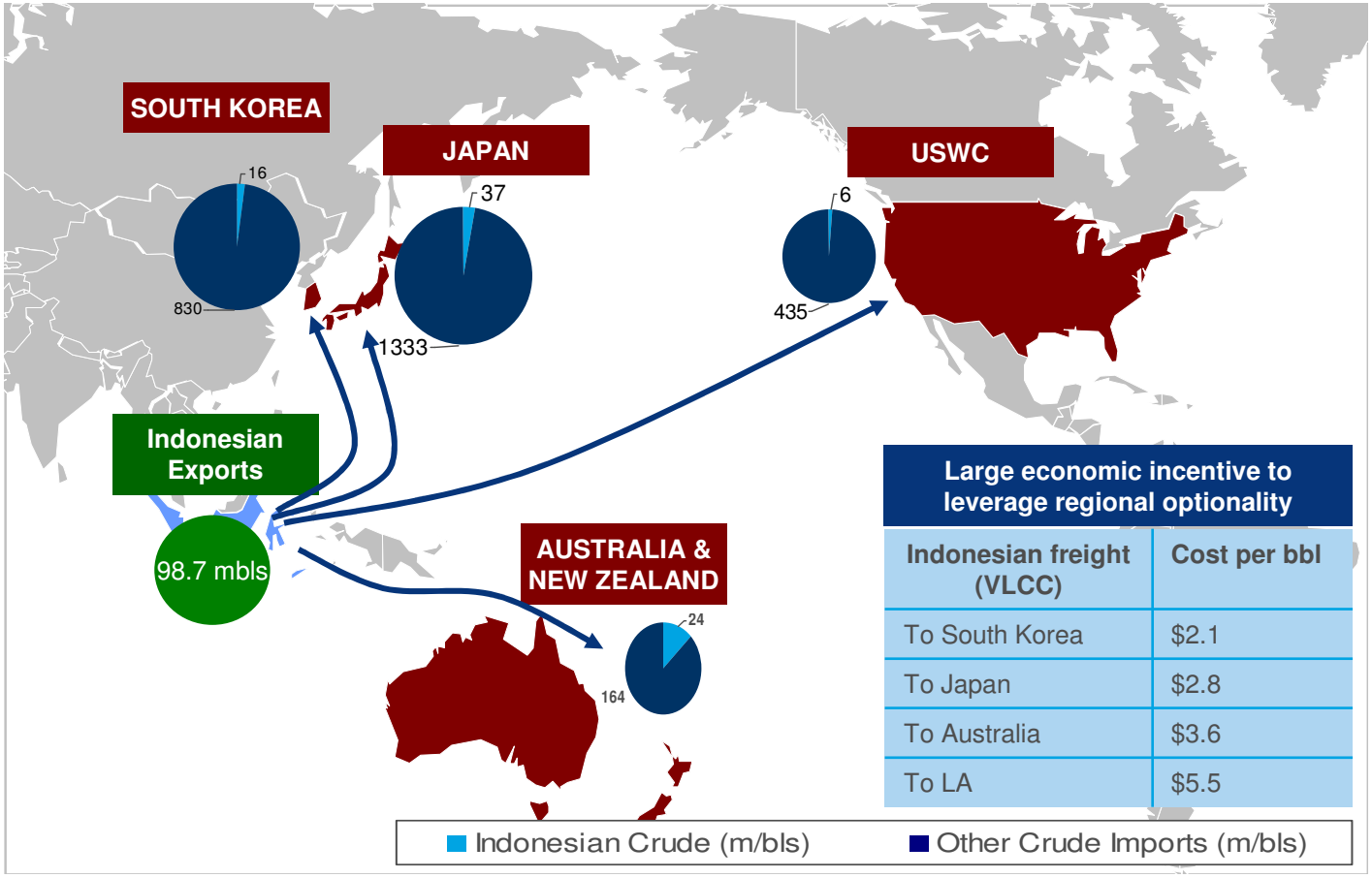
Mainly shipping transportation

Source	Approximate distance (km)
California	100
Saudi Arabia	24,000
Alaska	4,500
Iraq	24,000
Ecuador	6,300
Canada	2,500
Angola	16,300
Brazil	14,500
Colombia	7,000
Russia	19,900
Vietnam	17,700
Argentina	18,700
Oman	23,000
Indonesia	16,000
Mexico	9,400
Thailand	17,000
Venezuela	7,500

Growing Asian demand suggests Asian HCICO will remain in Asia and non-HCICO could get pulled into USWC, potentially raising GHG emissions

- **2006 Baseline includes no Indonesian crudes but an initial review of Indonesian crude by the CEC identifies a HCICO (Duri) and non-HCICO crude oils**
- **Asian crude oil demand is expected to increase from 23.5 million b/d in 2010**
  - HCICOs have access to local growing demand where no carbon policy is in place
  - Non-HCICO crudes, presently going into the regional market, could be drawn to California
- **This has potential carbon implications from**
  - the increased freight to the USWC
  - the push of regional HCICO out of the USWC, possibly into Asia

Freight re-balancing scenario using 2008 Indonesian crude disposition as an example

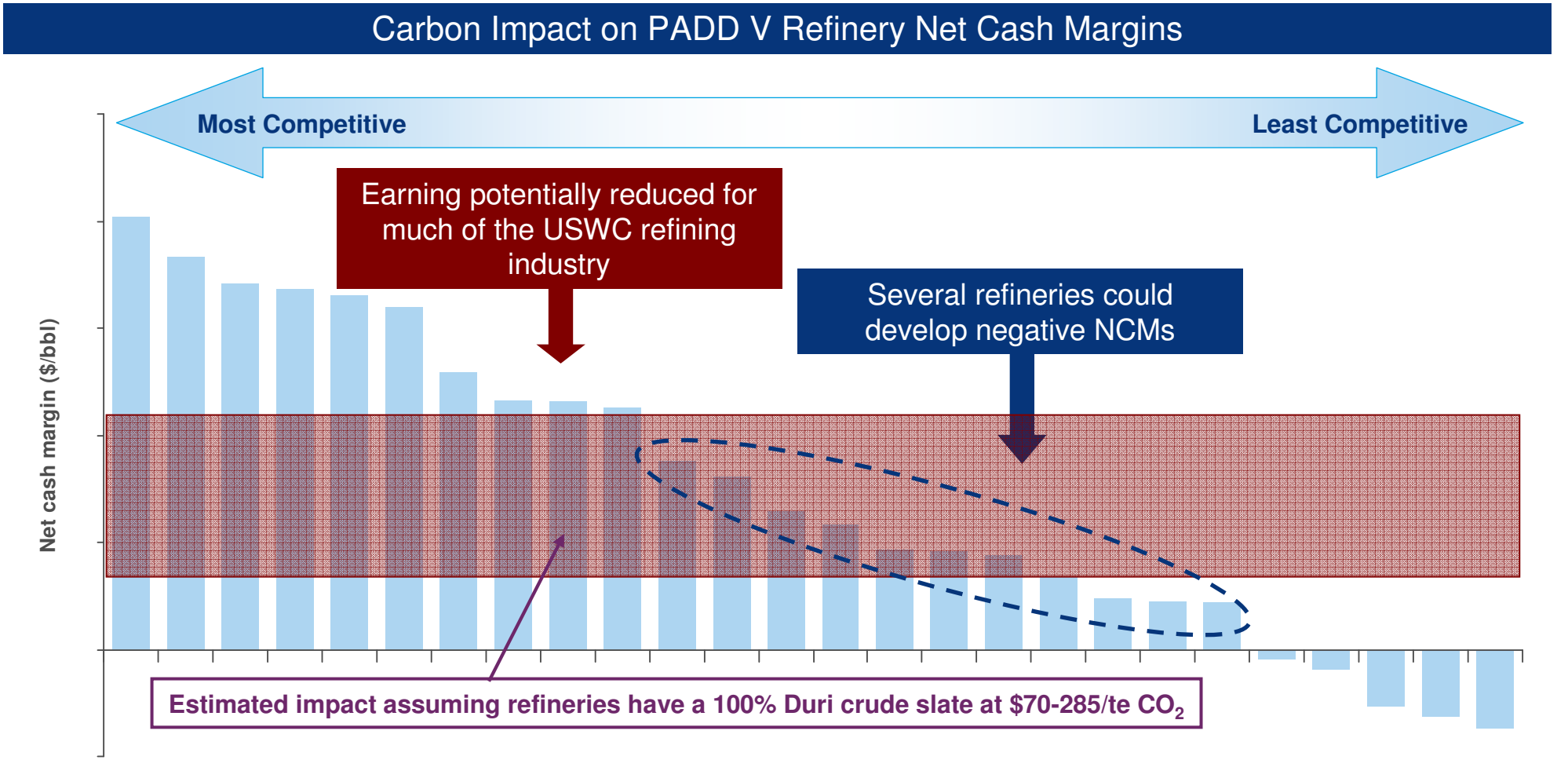


Large economic incentive to leverage regional optionality

Indonesian freight (VLCC)	Cost per bbl
To South Korea	$2.1
To Japan	$2.8
To Australia	$3.6
To LA	$5.5

Source: IEA, EIA, Wood Mackenzie, Clarksons, Worldscale

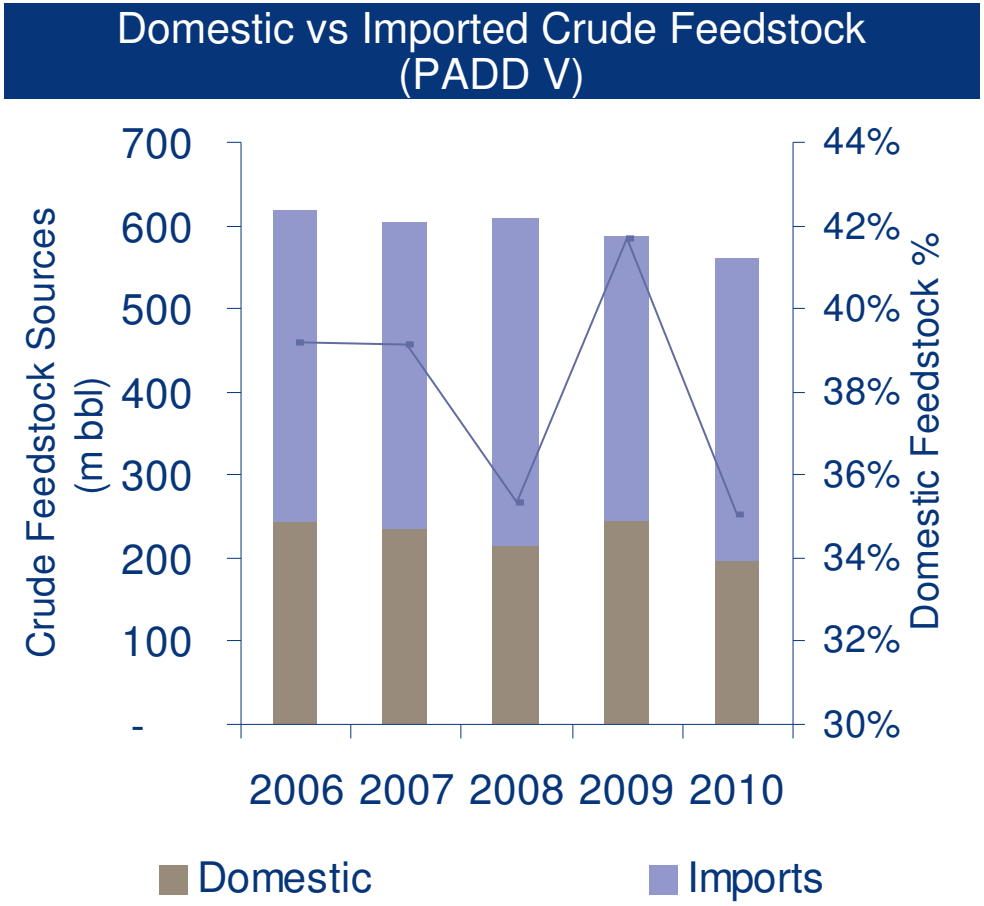
If PADD V refineries cover the regulatory burden of GHG on crude, potential compliance costs could be significant relative to typical refiners



Note: Earnings as assessed by Wood Mackenzie are net cash, with no interest or depreciation of past investments and no capital spending for the future

PADD V refineries require crude imports and they may face some of the carbon cost burden to ensure they receive crude supply

- **Coastal location gives refineries access to a large number of crudes and suggests a competitive supply market…**
- **Non-California producers are likely to have strong bargaining power and place the carbon burden on the refineries because:**
  - PADD V is deficit crude oil and requires large quantities of long-haul imports
  - These long-haul crudes oils have attractive alternative markets



Source: EIA, Wood Mackenzie

Assumptions were made to rebalance historic (2007-10) crude slates

- **We examine the historical crude slate based upon data from the EIA and Wood Mackenzie research**
- **Applying a $70/tonne carbon cost to the crude slate was then re-cast taking into account the following as to how the crude slate may / may not alter:**
  - Refinery production levels remain the same as historically
  - Refiners maintain the same crude slate in terms of the heavy / medium crude split
  - Californian and Alaskan North Slope crude slate could not increase beyond the historical number due to production limitations
  - High carbon crudes are sought to be replaced by crudes of a similar API but with a lower carbon cost
  - Delivered cost of crude is a consideration in sourcing alternative crude streams
  - Major crudes stream are generally deemed available whilst smaller crude streams have some limitations on increasing supply
  - Typical regional freight costs were applied
- **No attempt in this analysis has been made to re-balance the changed crude slate impacts on other regions due to the fact that**
  - Crude which would not have been used becomes available for other regions
  - Additional crude imports into the USWC take crude away from other regions
  - Rebalancing is assumed to not change historical prices

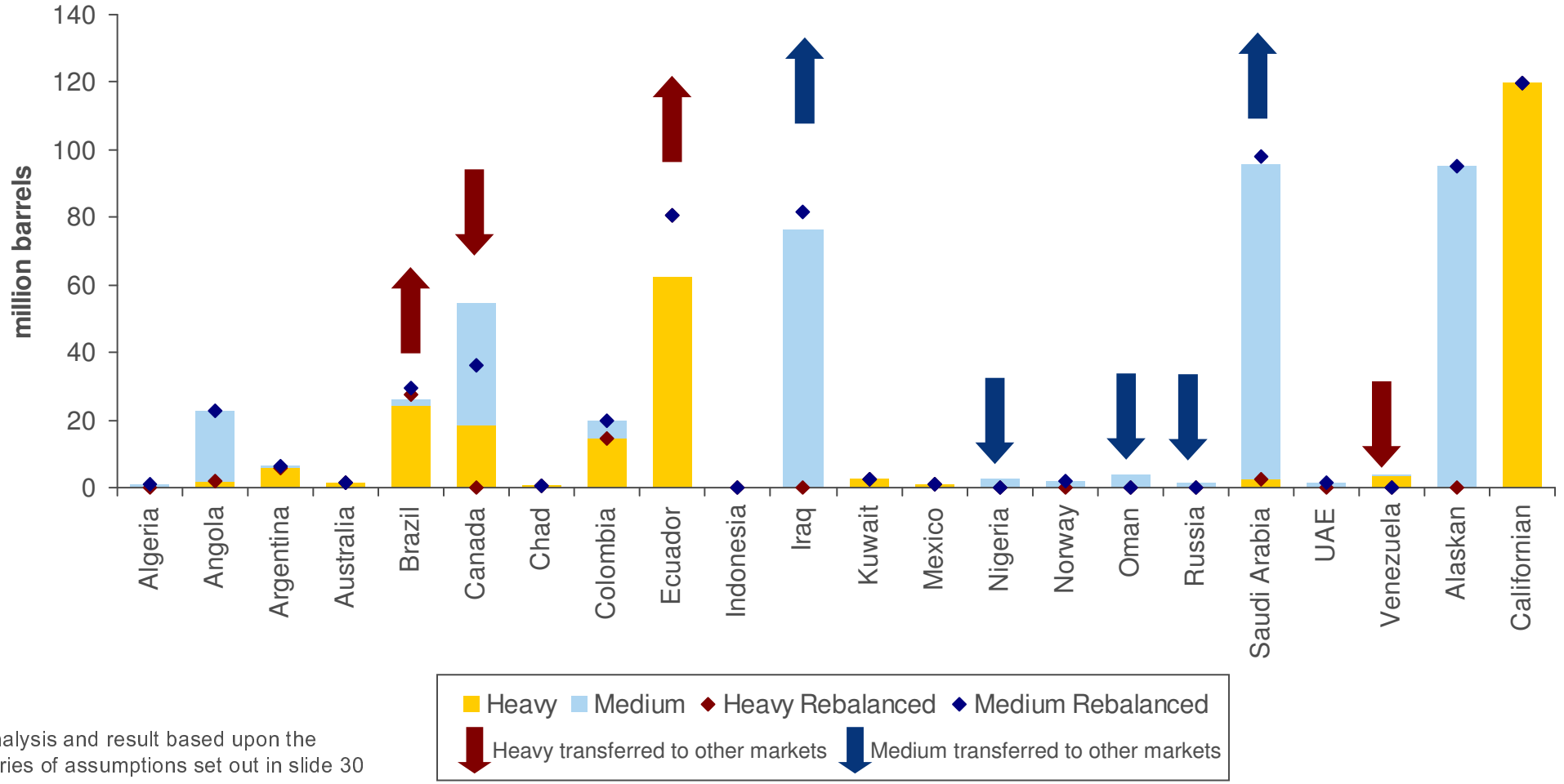
The imposition of the LCFS and HCICOs would have rebalanced the historic Californian slate towards the 2006 baseline crude oil mix

- **Rebalancing the historical crude slate would have pushed HCICOs out of the USWC market to other markets where no carbon restrictions exist**

- **Crudes which would have been expected to increase in a rebalanced history are those which fell within the 2006 crude baseline and which had large production capacity and exports into markets other than the USWC**
  - Crudes which meet these conditions are those from Brazil, Ecuador, Iraq and Saudi Arabia

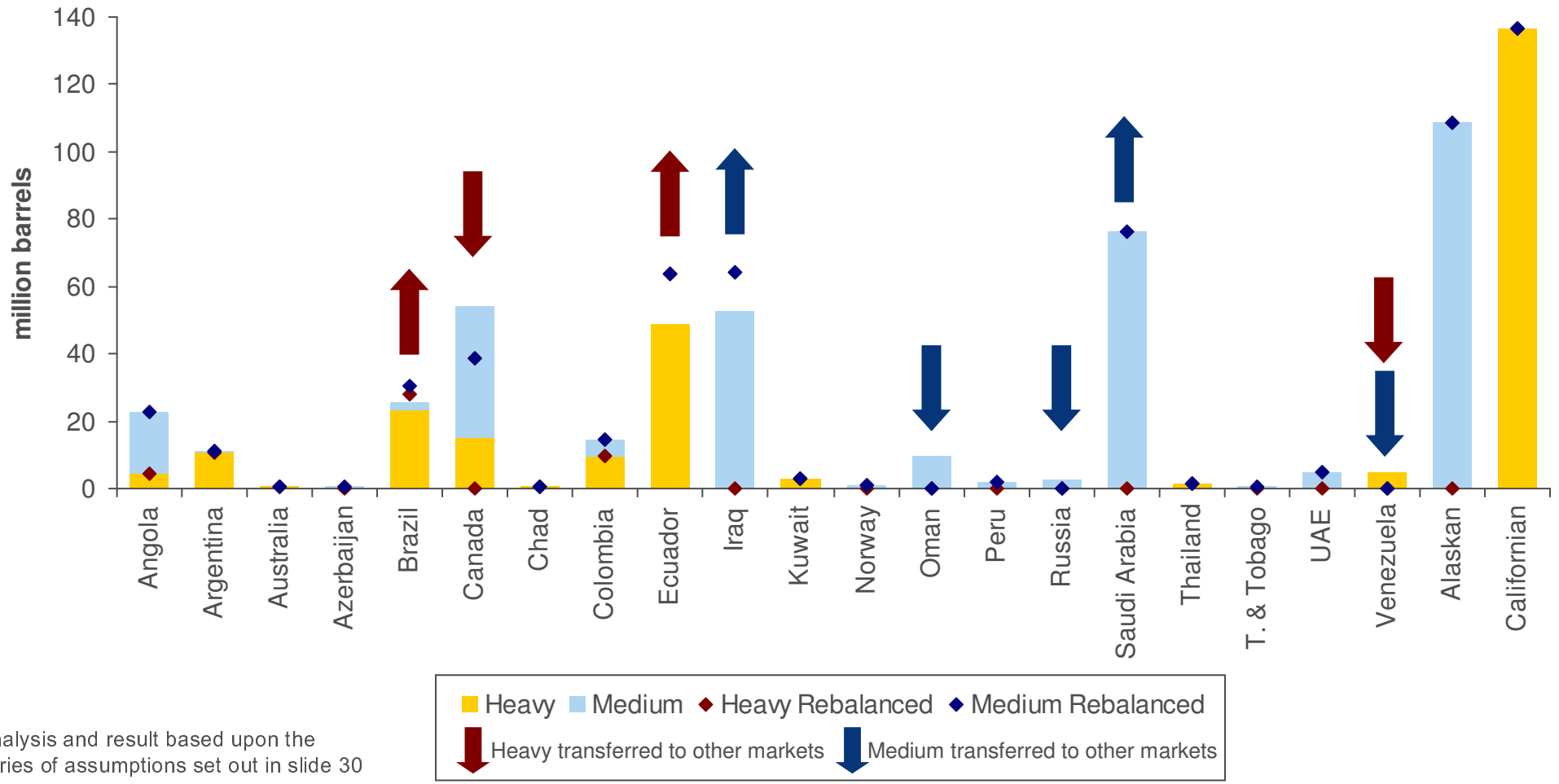
- **Crudes which would have not been used if the LCFS policy had of been in place are those that both fall outside the 2006 crude baseline and are considered to be HCICO**
  - Crudes pushed out of the USWC and into other markets would have included crude from Canada, Nigeria, Oman, Russia, Venezuela and Yemen

Rebalancing the 2008 crude slate would reduce Canadian and Venezuelan heavies and Nigerian, Omani and Russian medium



Analysis and result based upon the series of assumptions set out in slide 30

Rebalancing the 2009 crude slate increases ME, Brazilian and Ecuadorian crude



Analysis and result based upon the series of assumptions set out in slide 30

