California Integrated Waste Management Board
Emerging Technology Forum
April 17-18, 2006

Potential Renewable Transportation Fuels For California

Gary Yowell
Associate Automotive Engineer
California Energy Commission

Outline

- Commission's Role
- Energy Context
- Renewable Fuels
- Process Descriptions
- Conclusions

Commission Directives

- exploit all practicable and cost-effective conservation and improvements in the efficiency of energy use and distribution
- to achieve energy security, diversity of supply sources, and
- competitiveness of transportation energy markets based on the least environmental and economic cost. (PRC 25000.5)

Recent & Planned Reports

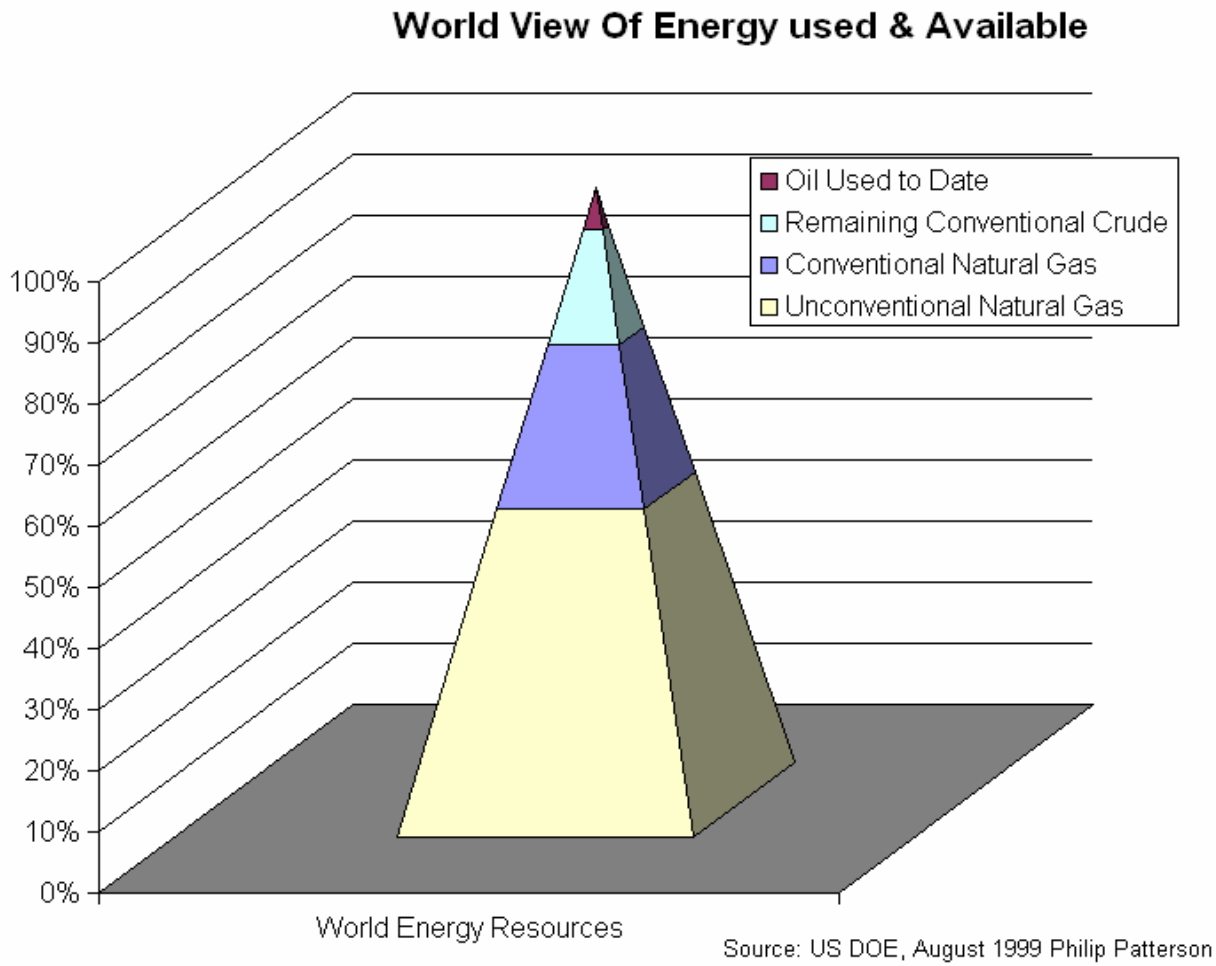
- 2001 Petroleum Reduction (AB 2076)
- 2003 Integrated Energy Policy
- 2005 Integrated Energy Policy
  http://www.energy.ca.gov/
- 2007 (AB 1007) Alternative Fuel Plan
  - Full-Fuel Cycle and Cost-Effectiveness Analysis
  - Plan for 2017, 2020, 2022 years

Prerequisites for a Sustainable Transportation Renewable Fuel

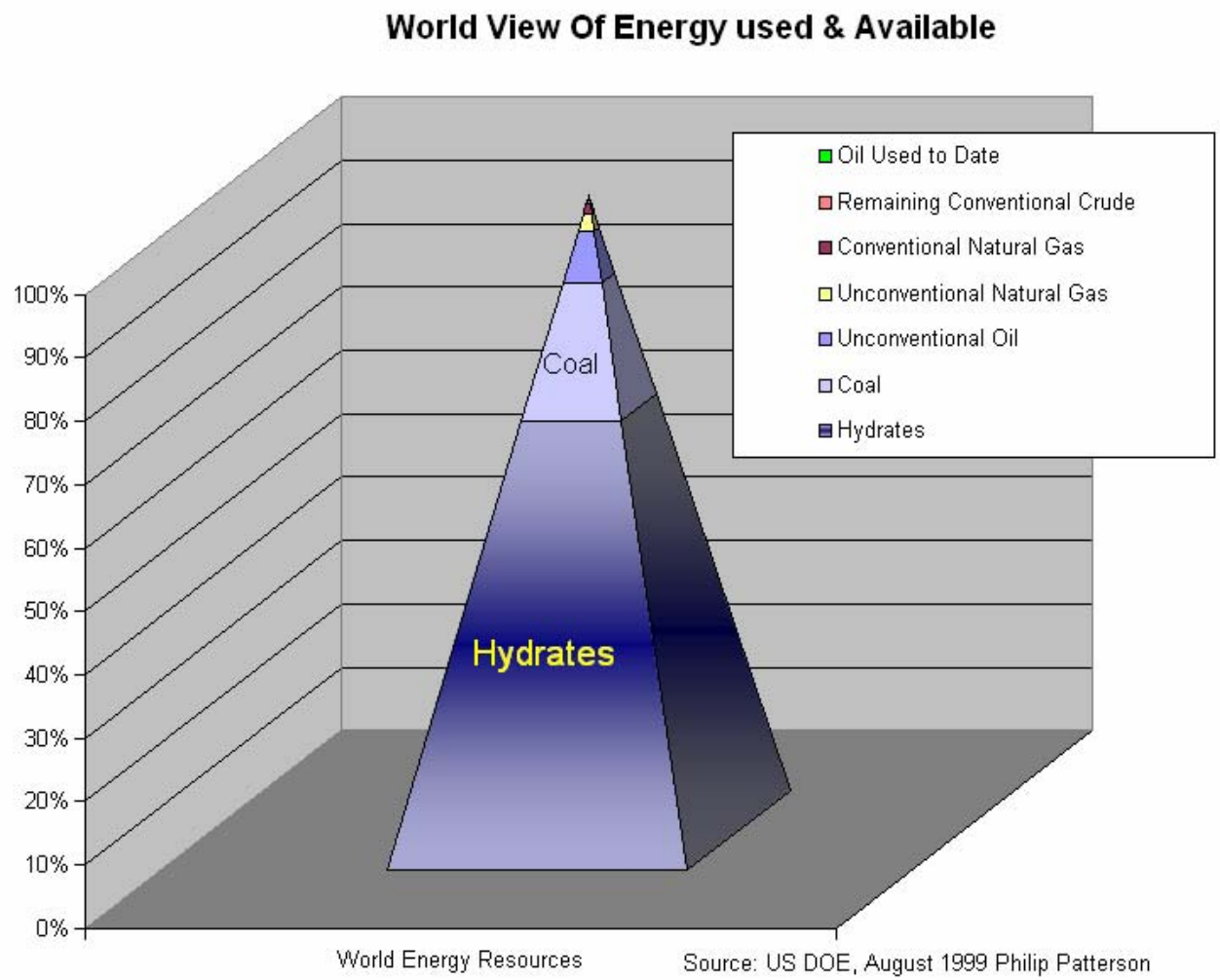
- Liquid at room temperature & pressure
- Compatible with existing petroleum-based infrastructure
- Compatible with old and future engines and vehicles
- Economically - competitive with petroleum based fuels

Energy Context

Are We Running Low on Energy?



Are We Running Low on Energy? - Full View

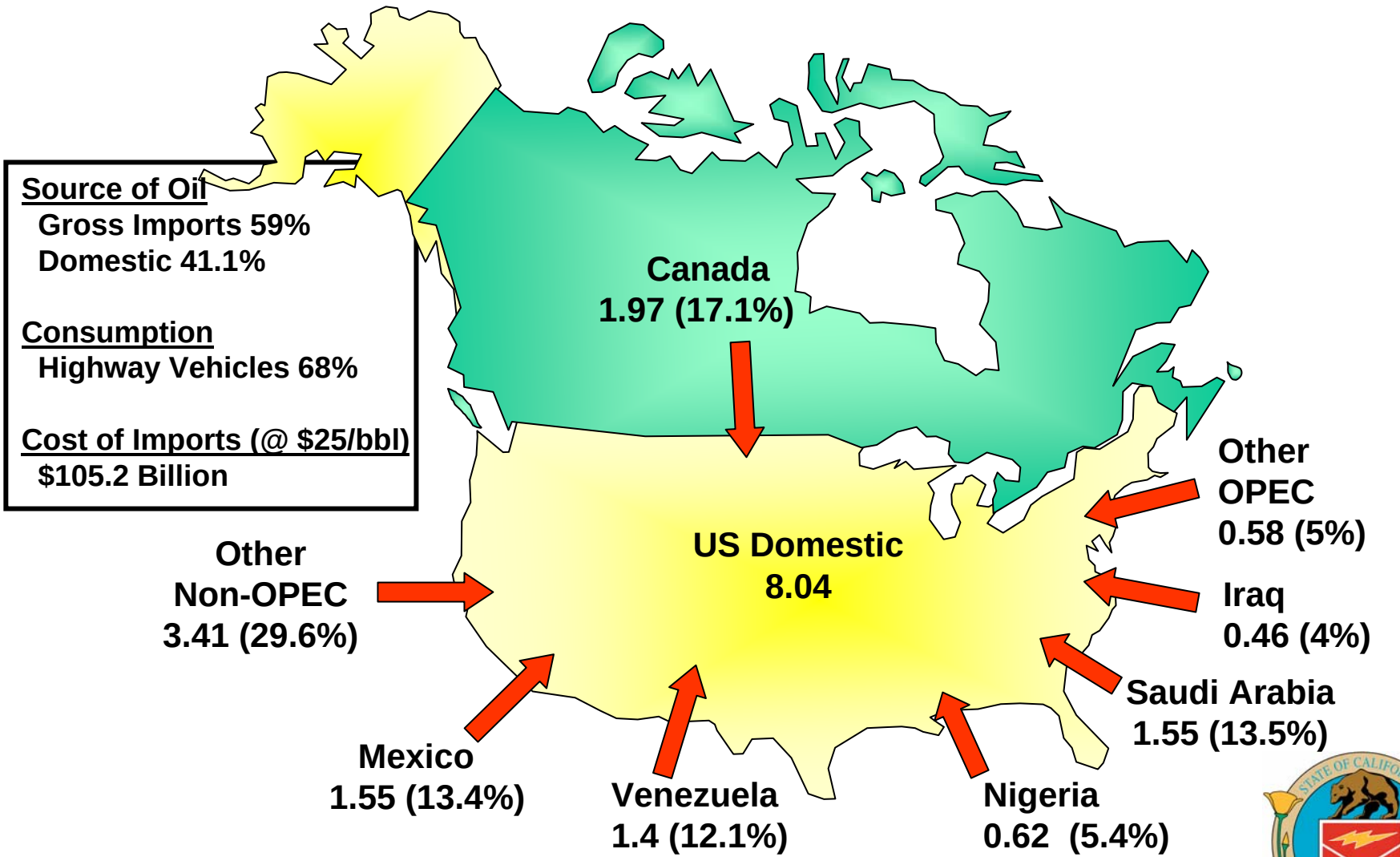


Key Points

- We are not running out of energy
- Running into higher-cost sources
- All resources are anticipated to be converted into liquid transportation fuels
- Renwables must compete within the “Crude oil World” with a few exceptions.
- World energy supplies are abundant but no guarantee that low and stable energy prices will be maintained

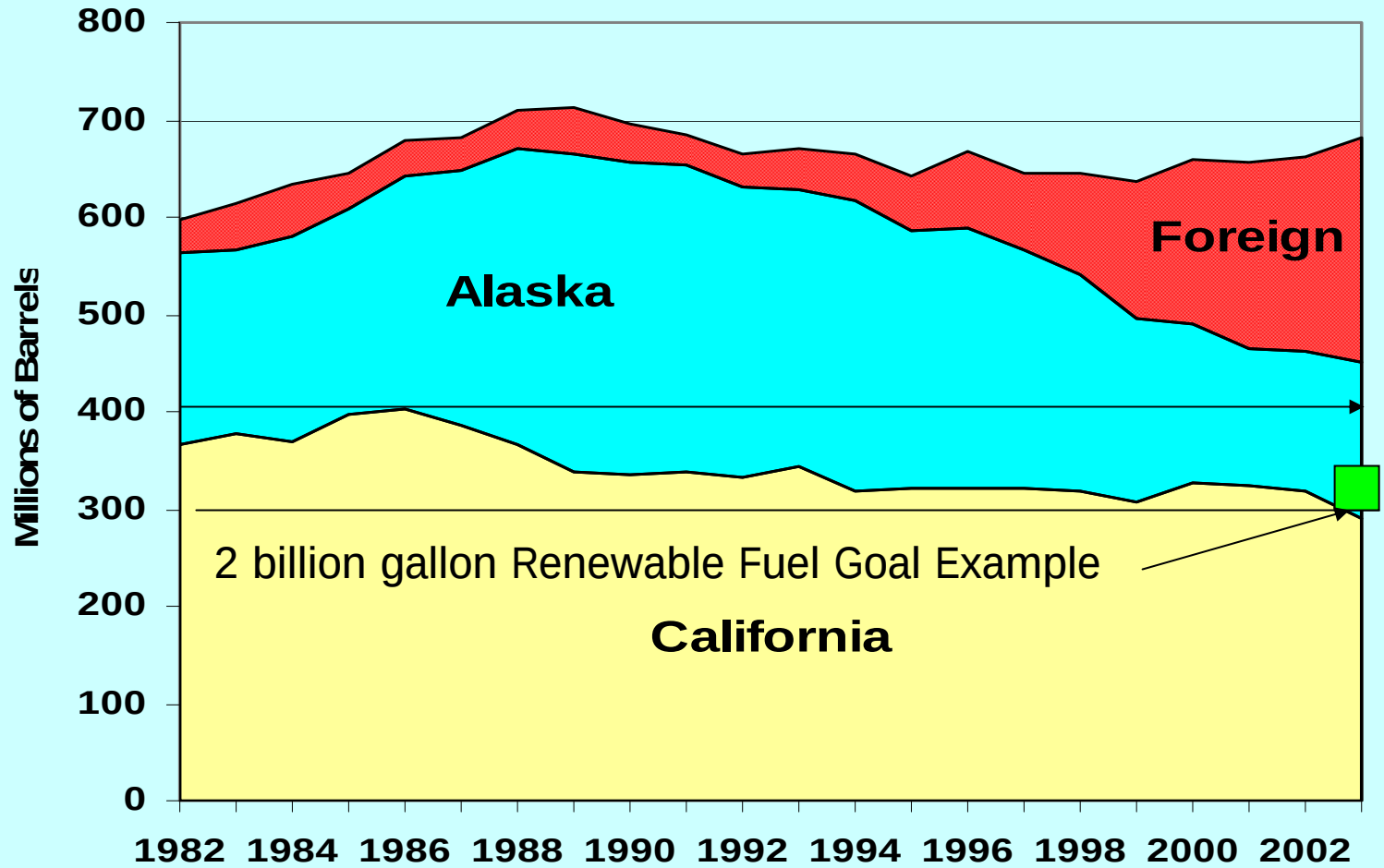
Our Oil Situation

(Millions of barrels per day)

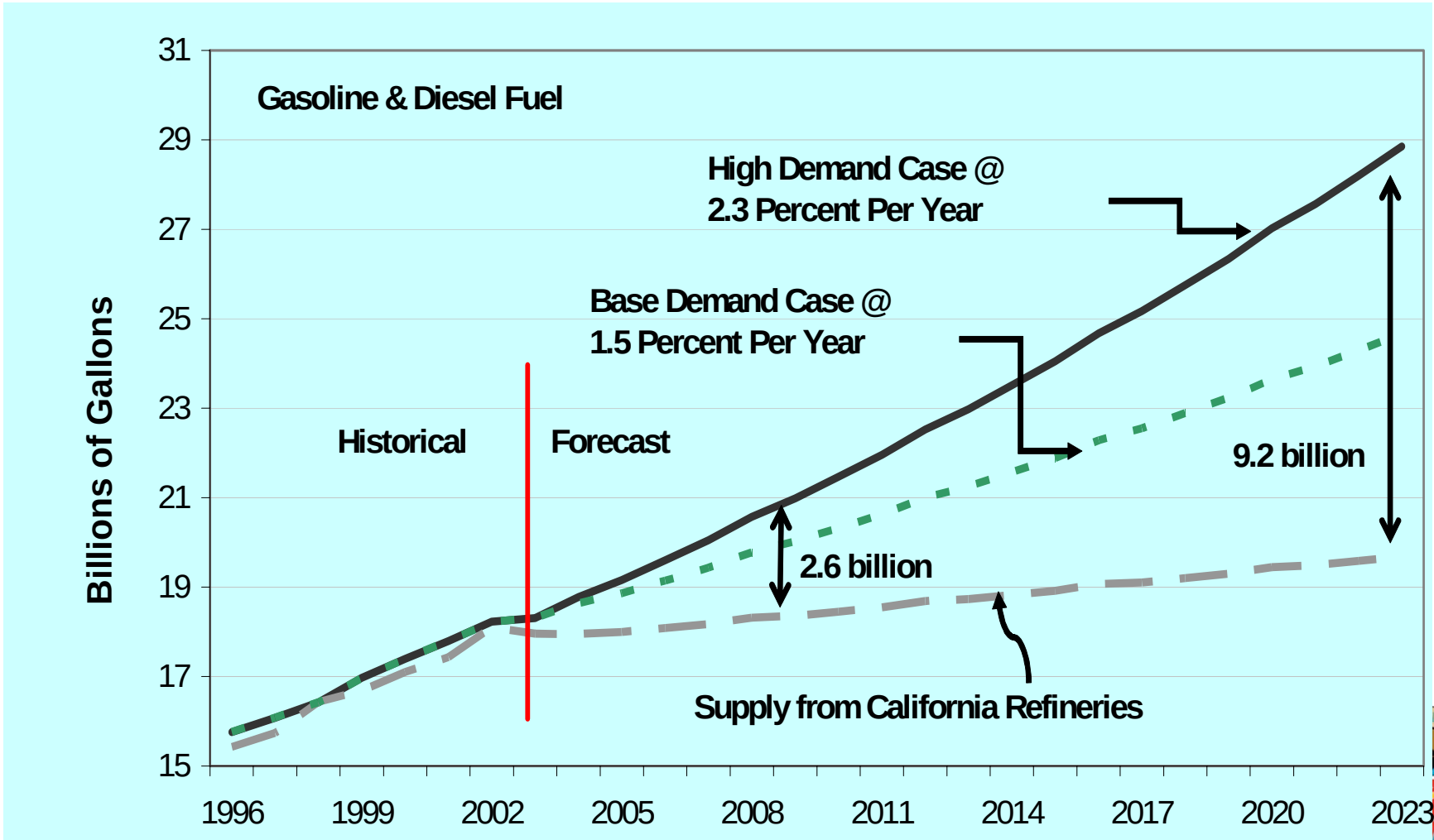


Source: EIA Petroleum Supply Annual 2002, Vol. 1

Crude Oil Sources For California Refineries 1982 - 2003

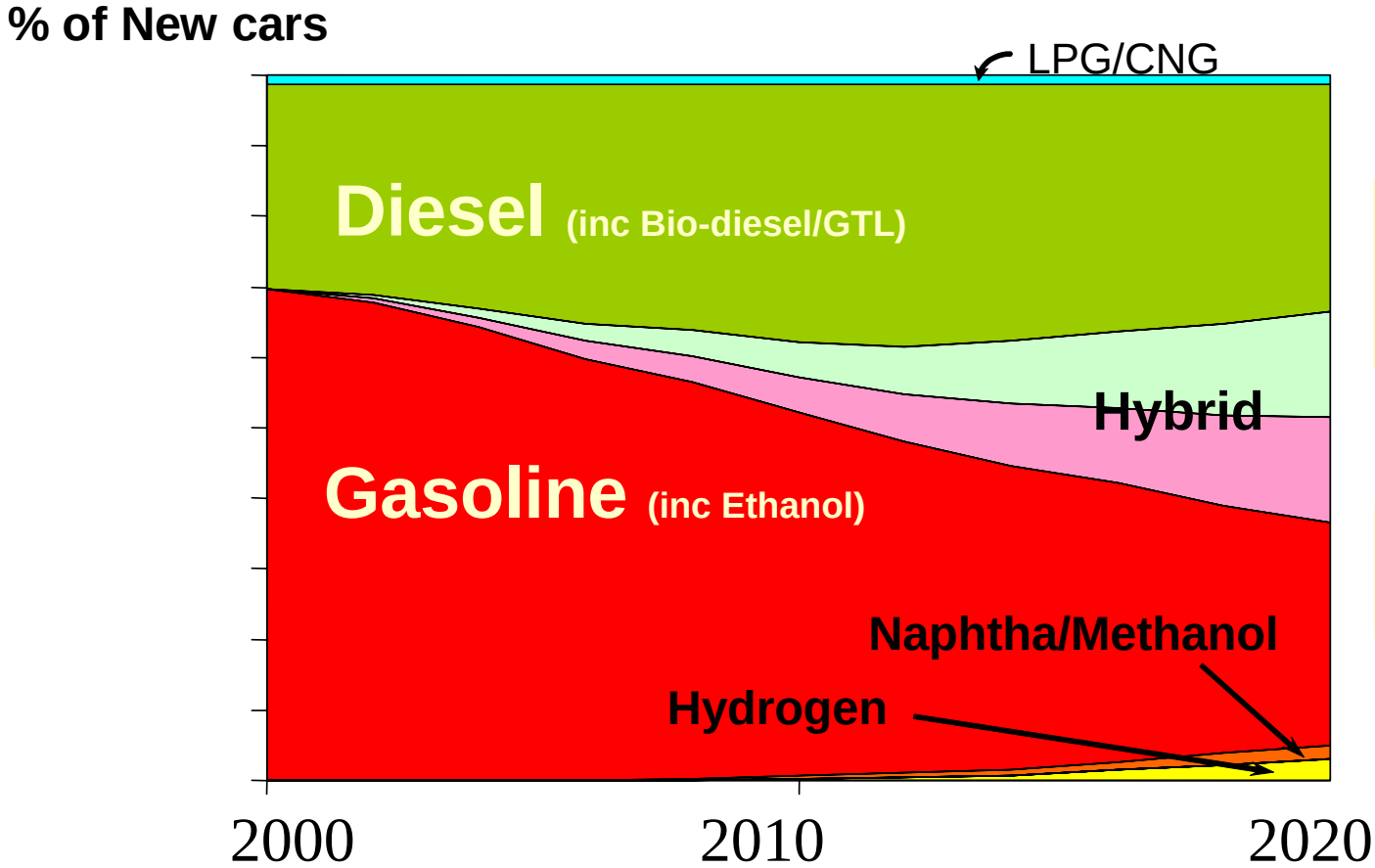


California Demand versus Local Supply



What's an Oil Industry Perspective?

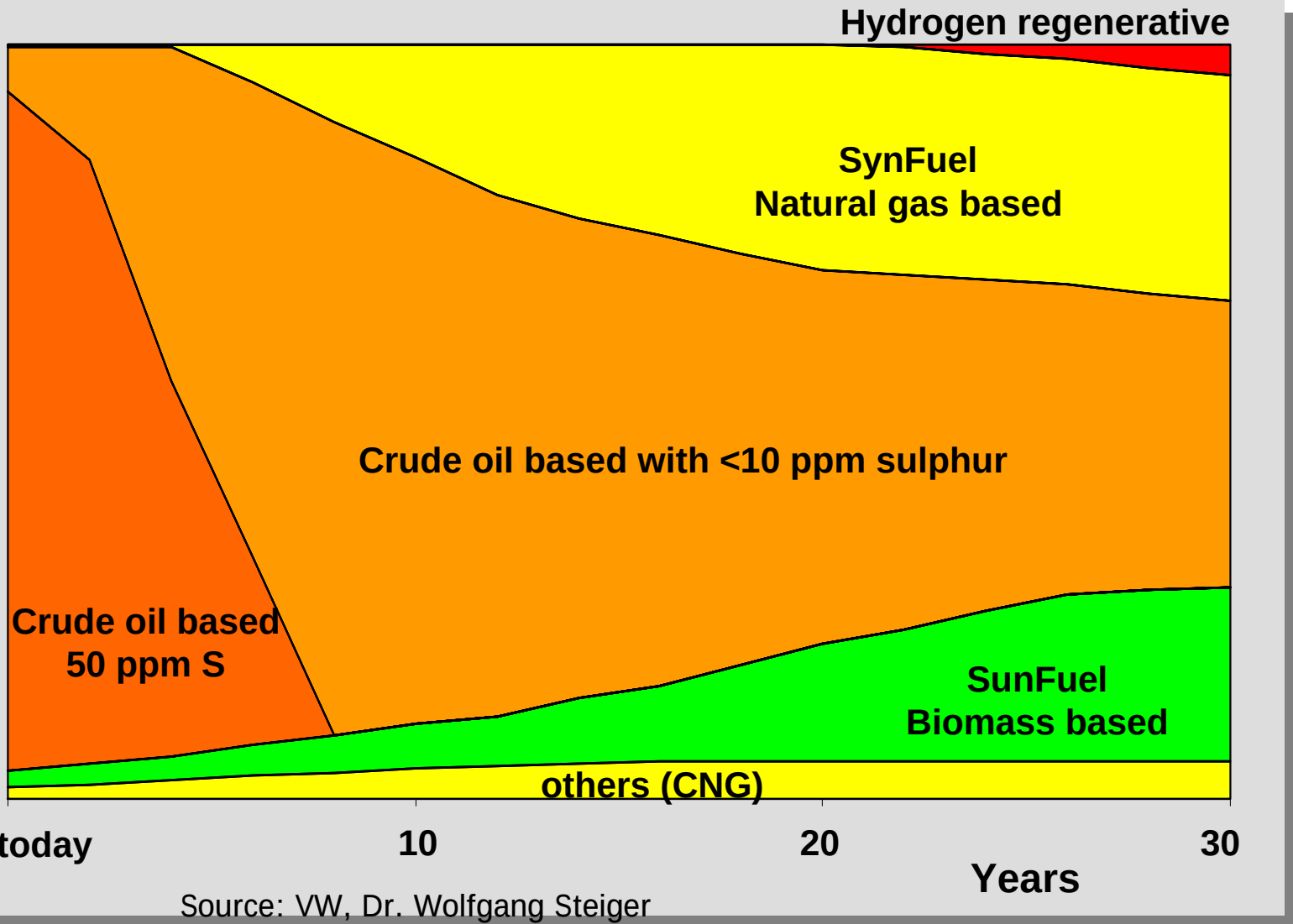
The next 20 years will see a wider range of technologies and fuel types, especially in the developed world



one possible view of the future - not a forecast

Source: Shell Global Solutions

Fuel Diversification Scenario Europe



Source: VW, Dr. Wolfgang Steiger

Renewable Fuels

List of Renewable Fuels & their Displacement Potential

• Ethanol Blends expanded to 10%	4.5%
• Bio diesel	< 20%
• Thermal Conversion- AKA Depolymerization (Turkey-Guts-to-Oil)	< 30%
• Neste NExBTL	< 10%
• Biomass-to-Diesel (Fischer-Tropsch)	< 30%
• Algae Diesel	?10-80%
• Ethanol E85 fuel (FFVs)	5-50%
• ~~Methane Digester Gas to CNG~~	~~0%~~

Just Say No to Renewable Methane Gas used in Transportation Applications

- Need to direct efforts to use renewable gaseous fuels into stationary and pipeline markets
- Limited (<6,000 vehicles) CNG vehicles in state & less anticipated in the future
- CNG cost/benefit analysis consistently finds no net benefit
- By 2010 diesel and natural gas vehicles will have no effective emission difference.

Alternative Diesel Fuels Incremental Cost Effectiveness

Fuels	Cost/petroleum-gallon saved	Potential Total Displacement
Propane	22¢	<20%
GTL	<25¢	>>50%
BTL	<$1.00	<30%
Biodiesel & Thermal Conversion Diesel	$1.00	<30%
Ethanol (E10) Ethanol (E85)	53 ¢ $1.00	>5% 30%?
Algae Diesel	???	10-80%??
CNG-LNG	$2.00+	?

Source: CEC Staff unpublished Cost Effectiveness Analysis

Analytically Renewable Fuels are Worth 30 cent more than petroleum fuels

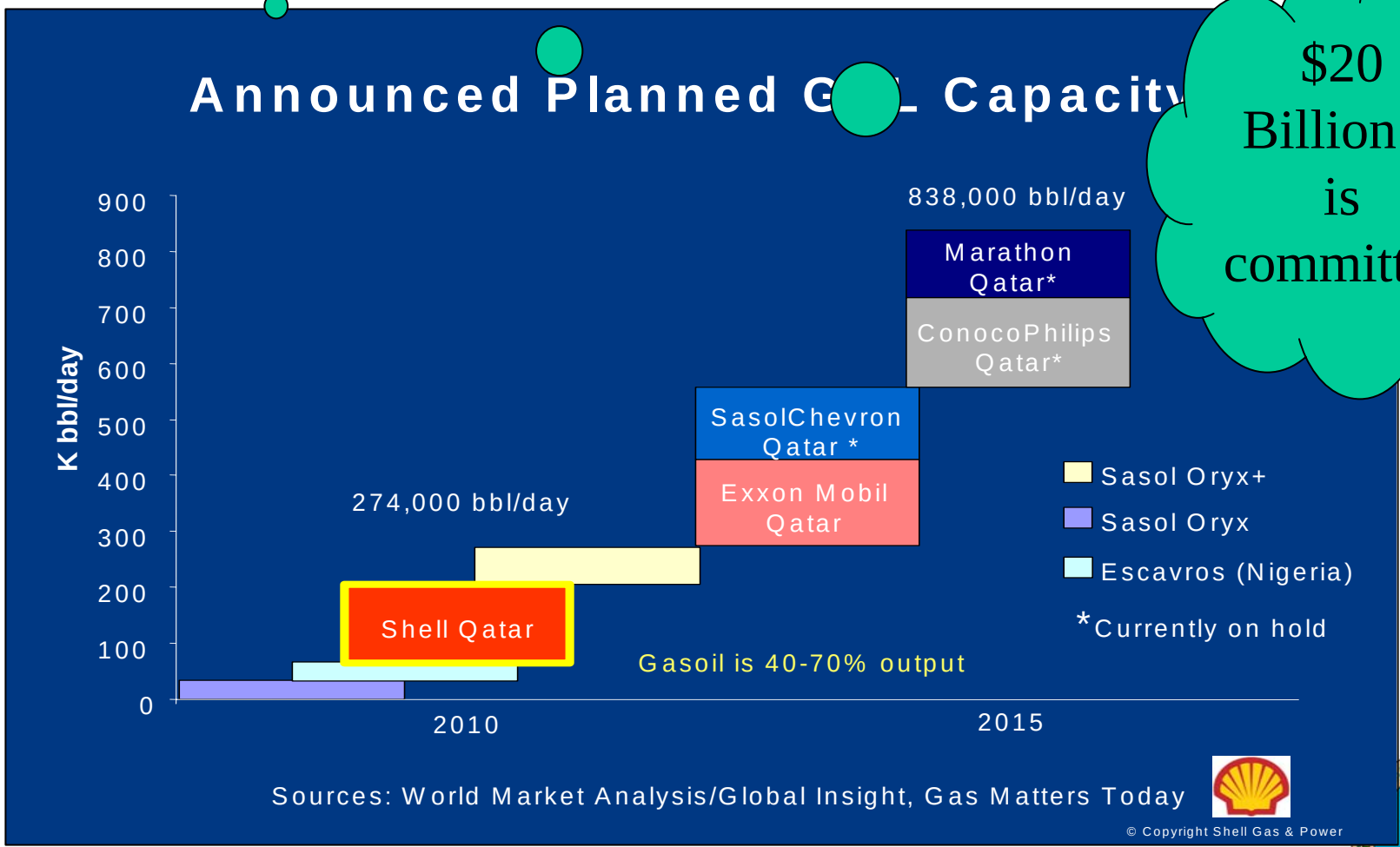
- Energy Security –Fuels diversity is presently valued at 12 cents per gallon
- CO_2 reduction is 14 cents per gallon
- Domestic in-state jobs creation ??
- Do we have the political will to put these type of values into state policy?

General Observations

- Most Active Interest in Renewable Fuels in over 15-years
- Most Active Legislation for Renewable fuels
- Advanced clean diesel car starting fall `06– will help pull Renewable Diesel Fuels
- China, India growing petroleum demand reinvigorates all to shift demand to other energy sources
- California Ethanol Production is a good fit with cattle industry feed needs.

Process Descriptions

Gas-to-Liquid (Fischer-Tropsch Process)

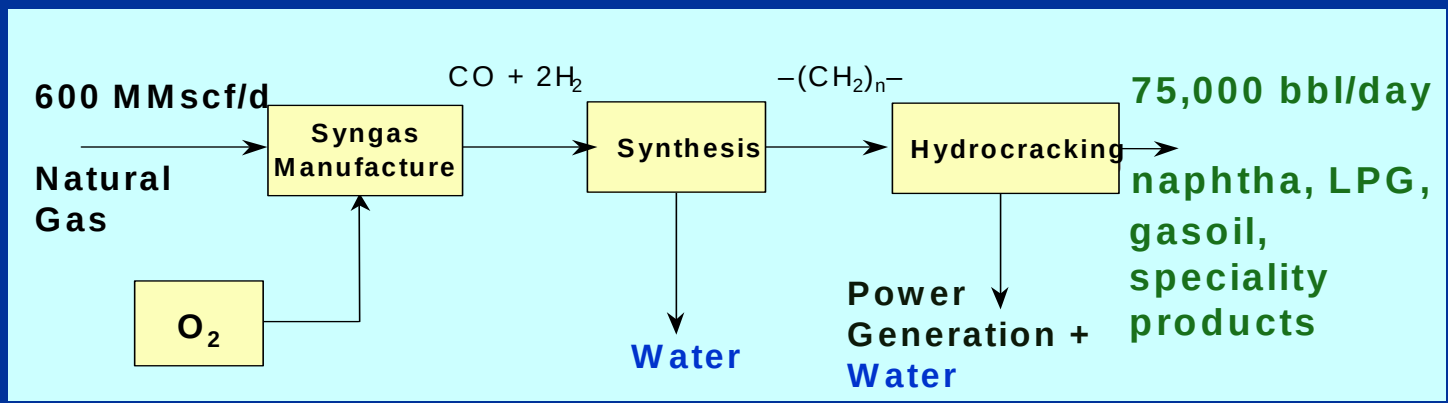


$20 Billion + is committed

Fischer Tropsch Processes

(Natural gas/Coal/Biomass)

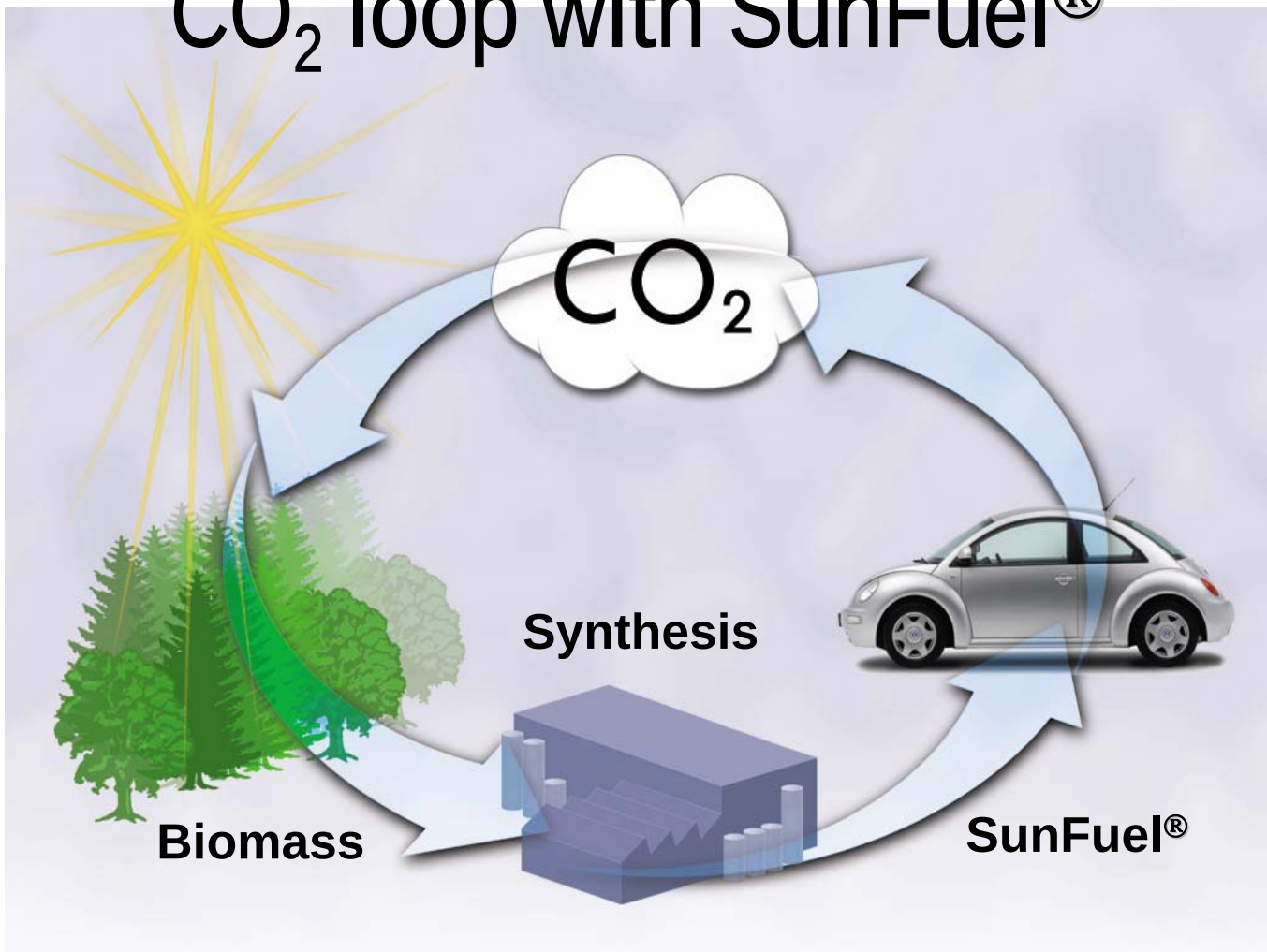
Shell GTL - Shell Middle Distillate Synthesis



Commercially proven technology, at Bintulu, Malaysia since 1993 ……

Ready for large-scale applications!

CO_2 loop with SunFuel®



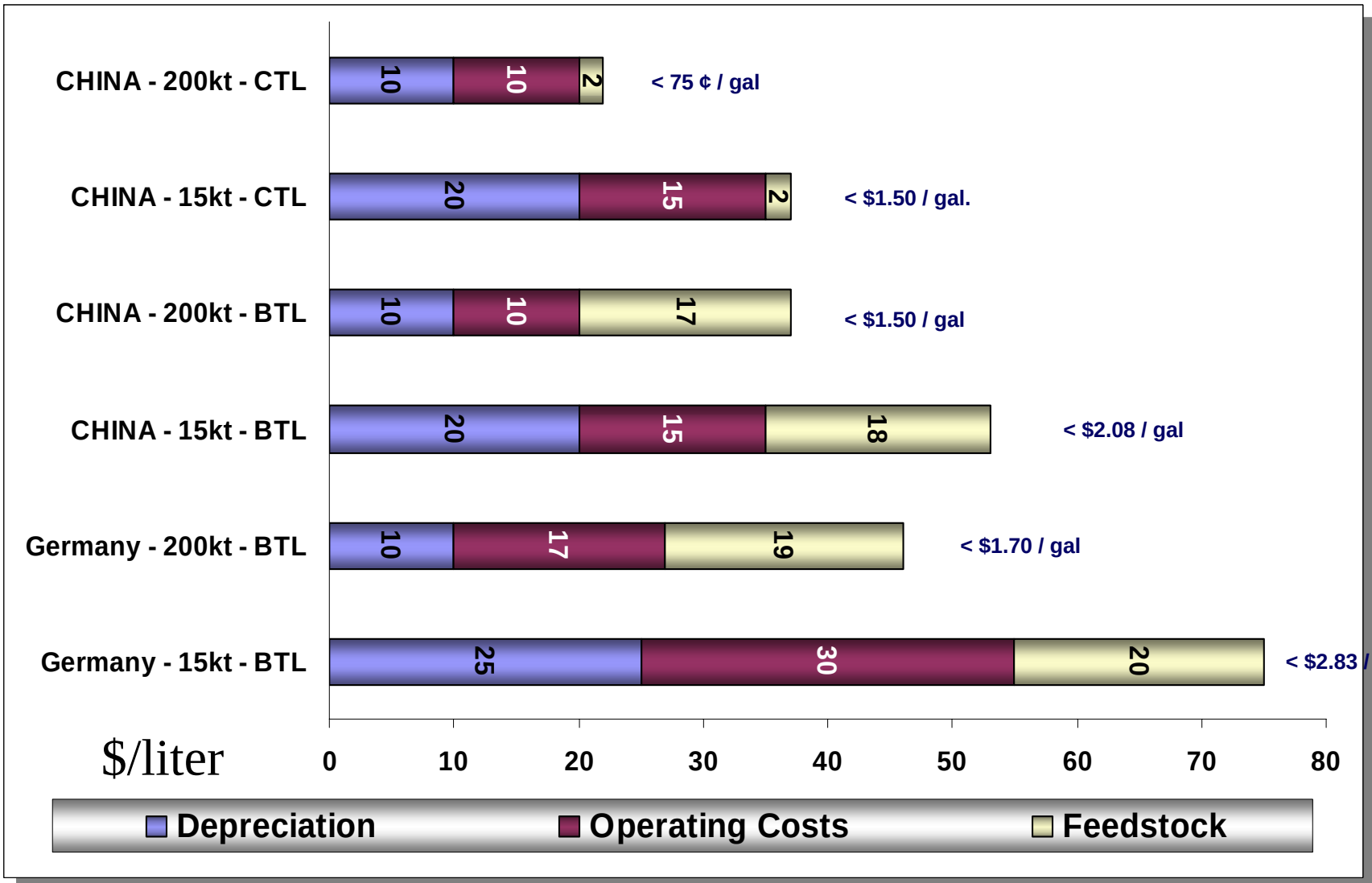
Source: VW, Dr. Wolfgang Steiger

Will Biomass-to-Diesel become a Commercial Reality?

CarboV® Test Facility CHOREN

Capacity:	1 MW thermal
Input:	wood
	Straw
	Green plants
	Shredder-Light-Fraction
	Coal
Products:	
currently.:	BioSynGas → el. power
in 05.2003 :	Diesel appx. 600ltr/day
	Kerosene
	Methanol

Estimated SynFuel Production Costs (¢/gal.)

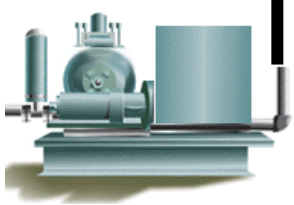


Changing World Technology
500 bbl/day Cartridge Missouri Plant

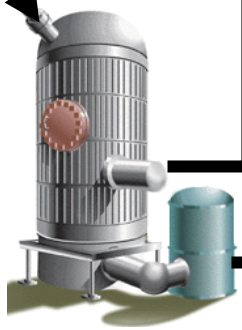
Changing World Technologies
Thermal Conversion Process

Feedstock Prep
- Mixing and pulping

Pressurizing and Heating



1st Stage Reactor
- Aqueous depolymerization
- 250°C and 50 atmospheres

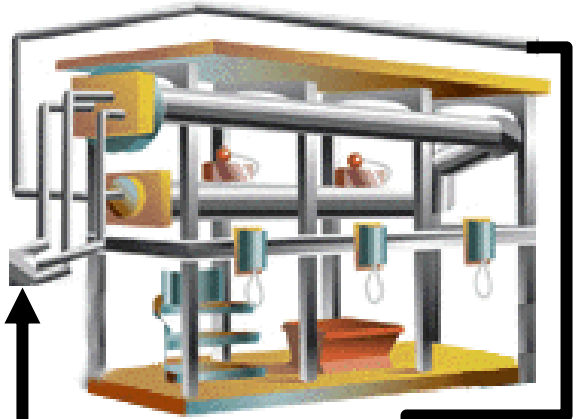


Flash Tank
- 1st stage product separation
- Organic oil to 2nd stage
- Water to evaporation
- Minerals to drying

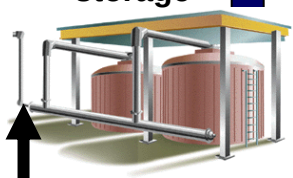
1st stage organic oil

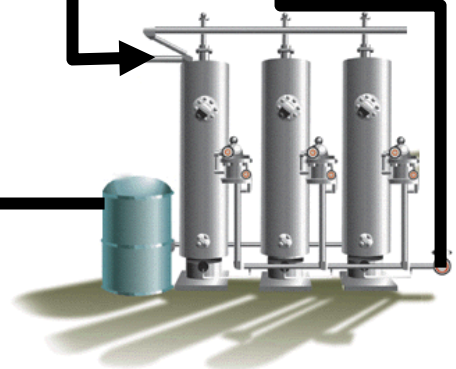
Water, minerals, solubles

2nd Stage Reactor
- Organic oil reforming
- Fuel-gas to power plant
- Bio-derived hydrocarbon oil to separation



Product oil storage

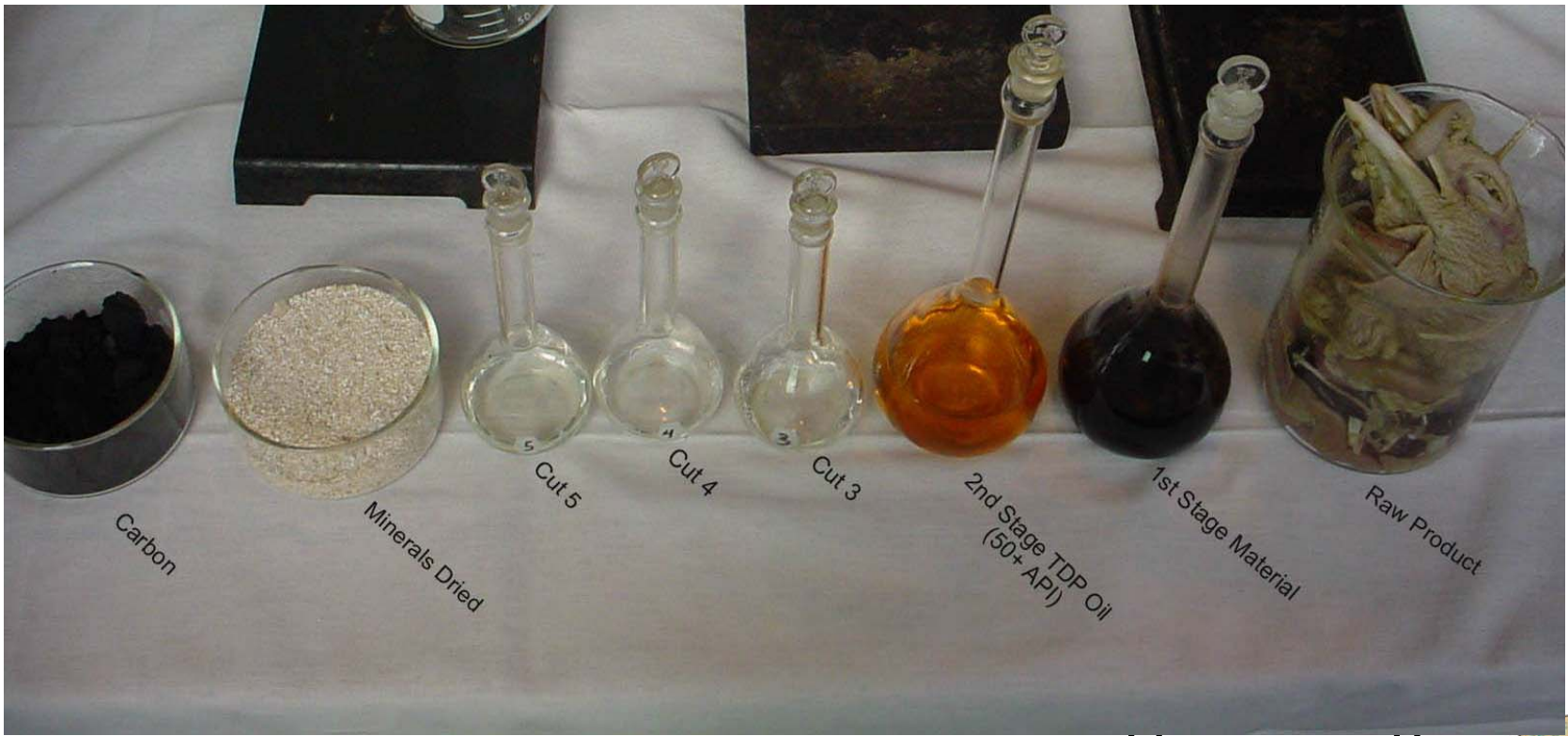




Oil Separation
- Water and solubles to evaporation

Fuels Meet
D-975
D-396

Thermal Conversion Process Products



Carbon | Minerals | Gasoline Splits TDP 40 | Diesel Split | Organic Liquor | Raw Product

Unique Potential of Algae Biodiesel – Near-term Energy Independence?

- Research and Development still needed to improve process
- 10 million acres of algae would supply ALL US transportation fuel
  - US currently uses 970 million acres for crops & grazing

Crop	Gal/Acre/ Year of Oil
Soybean	48
Peanuts	113
Rapeseed	124
Coconut	287
Palm Oil	635
Algae	15,000

Commercial Algae Farm Irvine Ca

Neste - NExBTL

NExBTL is a 2nd generation Renewable Diesel That Combines the benefits of GTL-diesel and Biodiesel
–Premium fuel properties like GTL
–Reduces exhaust emissions like GTL (or even lower)
–Fits existing infrastructure and engines
–CO_2 savings like Biodiesel (or even more)

•Feedstock diversity
–Waste animal fat
–Soy, corn, canola, rape and other vegetable oils

•60 million gallons, summer 2007, $120 million investment.
•The Commission is working to keep the door open to 2nd generation renewable fuels like NExBTL

NESTE OIL

Fuel Property comparison

	NExBTL	GTL	FAME (RME)	Sulfur free Diesel fuel (summer)
Density at +15°C (kg/m^3)	775 ... 785	770 ... 785	≈ 885	≈ 835
Viscosity at +40°C (mm^2/s)	2.9 ... 3.5	3.2 ... 4.5	≈ 4.5	≈ 3.5
Cetane number	≈ 84 ... 99 *	≈ 73 ... 81	≈ 51	≈ 53**
Cloud point (°C)	≈ - 5 ... - 30	≈ 0 ... - 25	≈ - 5	≈ - 5
Heating value (lower) (MJ/kg)	≈ 44	≈ 43	≈ 38	≈ 43
Heating value (MJ/l)	≈ 34	≈ 34	≈ 34	≈ 36
Polyaromatic content (wt-%)	0	0	0	≈ 4
Oxygen content (wt-%)	0	0	≈ 11	0
Sulfur content (mg/kg)	< 10 (< 1)	< 10	< 10	< 10
Carbon / hydrogen	≈ 5.6	≈ 5.6		≈ 6.0

*) Blending cetane number
**) ASTM specification > 40

Which Process to Use?

- All processes will participate in the market
- Emissions reduction has played an important role in the past - not so much in the future (except CO2)
- Production volumes and economics are supplanting environmental issues

There are competing options to producing more fuel - 237 MPG Future?

VW 1-Litre Car

- 0.3 l SDI 1cyl.
- 6,3 kW (8,6 PS)
- 0,99 l/100 km
- Euro 4 limits

... demonstration of feasibility

Source: VW, Dr. Wolfgang Steiger

Conclusion

- Liquid Renewable Fuels, miscible with existing infrastructure and equipment are viable transportation options
- Gaseous (renewable) fuels are not a viable transportation fuel option
- Strong national and state government interest to expand renewable fuels.
- Help – us with AB 1007

Gary Yowell
916-654-4698
gyowell@energy.state.ca.us