



Pet Coke Consulting, LLC

Long Term Pet Coke and Coal Outlook

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Argus Conference, Houston

September 19-21, 2012



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**Will Pet Coke continue to be
made over next 25 years?**



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To answer, we need to know:

- **What drives pet coke production?**
- **How will those drivers change?**
- **What must happen to make the change**



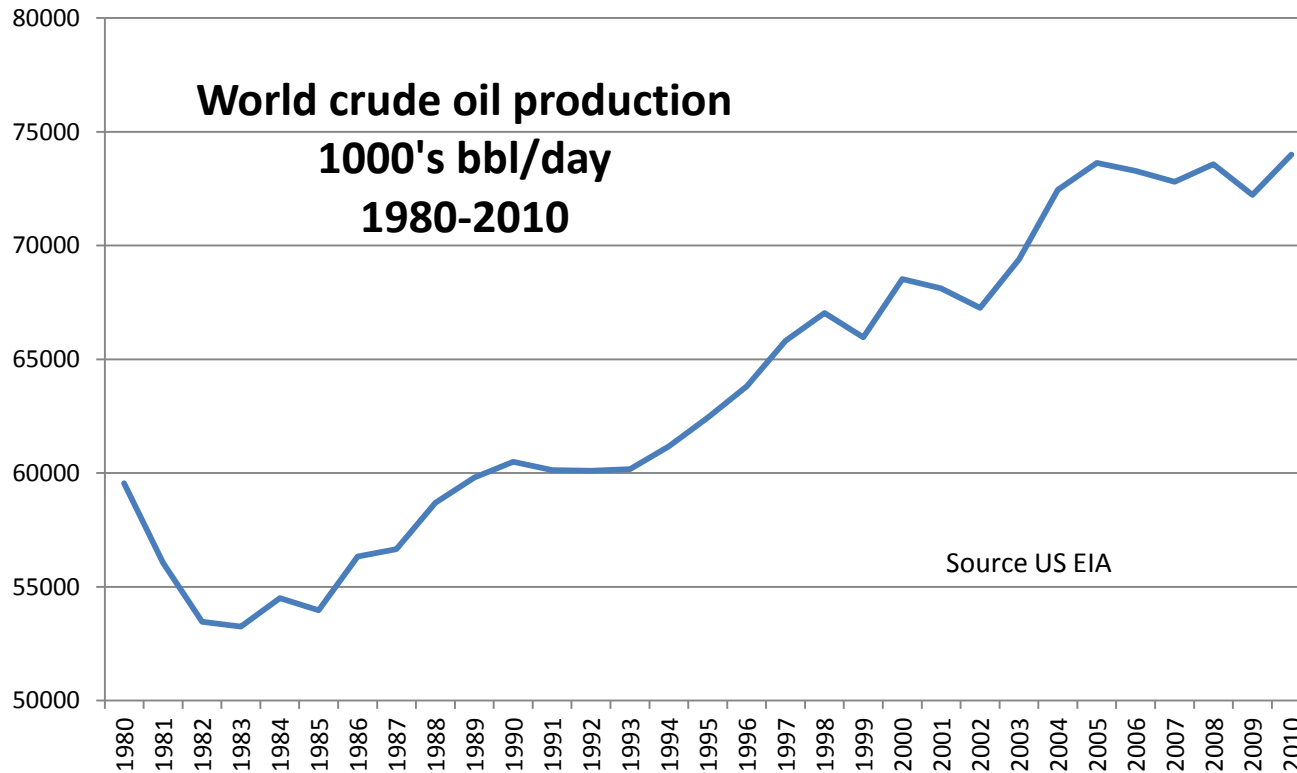
Pet Coke Drivers:

- Price of Pet Coke is irrelevant
- Refineries must meet global oil demand
- Coker Margin: Need enough light-heavy spread (“LHS”) between coker feed (heavy resid) and light products (gasoline, jet and diesel) to run the coker



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Crude oil demand continues to grow globally; Refining capacity will match it





Max Pet Coke

- About 105 million mt/year of pet coke produced today
- At 5 -10% pet coke yield from crude oil, if all current 75 million bbl/day of crude oil were coked, it would make 275-550 million mt/y of pet coke
- Even if global oil demand dropped by 50% , there still would be potential for 135- 275k mt/yr of pet coke, **if LHS supports it**



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So will the LHS spread support Cokers?

LHS is driven by demand for the lighter products (gasoline, diesel and jet) vs. heavier products (asphalt and bunker fuel)



What can happen to light products demand?

The only likely force to significantly reduce light products demand is action on solving the Greenhouse Gas (“GHG”) problem for vehicles:

- Carbon tax on gasoline, diesel
- CO2 tax
- Tax incentives for non GHG vehicles
- Penalties/fees for GHG vehicles



Can we go to non GHG vehicles & how do we get there?

- LPG as a fuel? – Makes CO₂, requires LPG storage at service stations
- Compressed Nat Gas (“CNG”) as a fuel? – Makes CO₂, requires pipeline capacity improvements and compressors at service stations
- Hydrogen? - No CO₂, but jury still out if energy to make it is less than energy released when burning it. Delivery system?
- Electricity? - Can fuel at home, but.....



Electricity can solve the GHG problem for vehicles, except:

- Electricity made from gas, coal, oil, LNG, or pet coke makes CO₂, although power from gas produces about half of the CO₂ as power from coal
- Already using all hydro, so left with solar and nuclear
- But nuclear still has issues re: safety (Fukushima, Japan) and waste disposal (Yucca Flat, Nevada)
- Solar investment in both generation and in the vehicle battery is expensive
- But solar is all that is left with proven technology for zero CO₂



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So, how far to reduce light product demand to stop running cokers?

In US, light products demand forced down to 60% of total oil products demand (vs. 76% now in US) might do it.



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**If we had to get to 60% light
product demand in 2035 with both
hybrid and electric vehicles from
solar power:**



US oil products demand profile in 2035 to get to the magic 60%:

	2011	2011		2035	2035
	MBD	% of total		MBD	% of total
Gasoline	8,740	47.7%		3,860	28.3%
Truck diesel	2,850	15.6%		1,260	9.2%
Rail diesel	1,000	5.5%		1,270	9.3%
Jet	1,430	7.8%		1,810	13.2%
FO, asphalt Lubes, LPG	4,300	23.5%		5.46	40.0%
Total	18,310	100%		13,660	100%
Memo % light products		76.5%			60%



How to get there: US gasoline

1%/yr growth in car miles driven

		2011	2035
Car miles	trillions	2.95	3.74
Gasoline demand	Thousands bbl/day	8.74	3.86
Hybrid/gas cars,	millions	268	204
All electric cars,	millions	0	136
Total all cars		268	340
Efficiency, Hybrid/gas cars	mpg	22	38
Efficiency, All electric cars,	kw-hr/mi	.35	.31
Gw-hr/year required		0	465,000
Sq miles of solar ranch land required		0	4,060



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Land for the Required Solar: US Gasoline Replacement only

	1%/yr mileage growth	3%/yr mileage growth
Solar Ranch Land required for all electric cars	4,060	6,500
Area of Los Angeles, sq miles	500	500
Number of solar ranches size of Los Angeles	8	13



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Solar Ranch Example: The Desoto Solar Ranch, Arcadia Fla.

DeSoto Next Generation Solar Energy Center





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The Desoto Solar Ranch, Arcadia Fla.

- 90,500 solar panels
- 235 acres
- \$150 million to build
- 25 MW installed
- 19.8% op factor (night, clouds, angle)
- 114.4 GW hr- year/sq mile



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Desoto Solar Plant vs. Conventional coal/gas plant

	Desoto Solar	Coal/Gas
Nameplate MW	25	500
Operating Factor	19.8%	95%
Average Output, MW	4.8	475
Build Cost, Millions \$	150	1200
Build Cost per Avg Output, \$/KW	\$31,250	\$2,520
Hours in 30 years	263,000	263,000
Build Cost \$/kw-hr over 30 years	\$0.12	\$0.01
Fuel cost \$/kwhr	0	\$0.03*
Total fuel and Build cost, \$kw hr	\$0.12	\$0.04

* \$3.00/MM BTU at 10,000 BTU/kw-hr



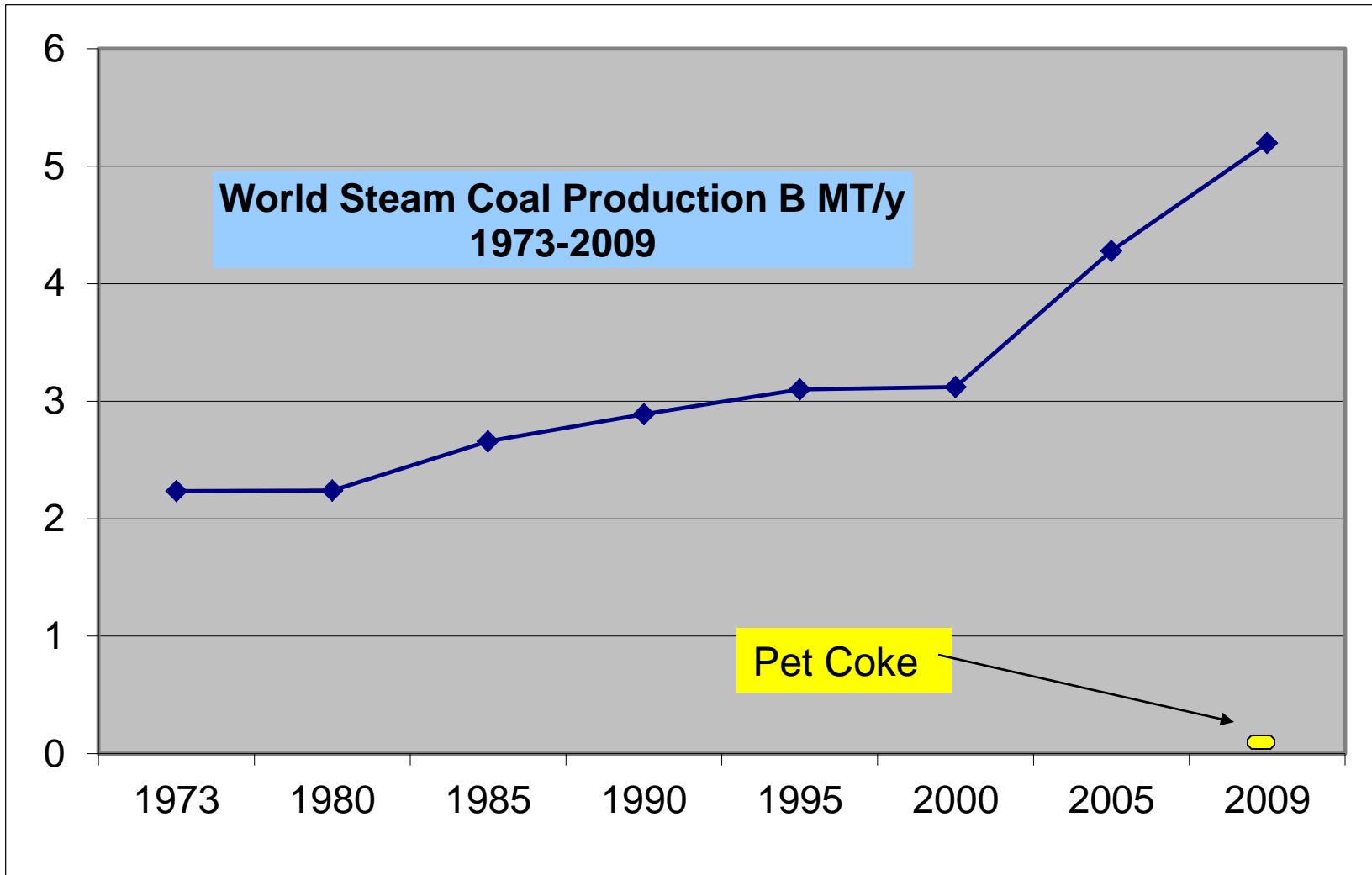
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Coal Long Term Outlook

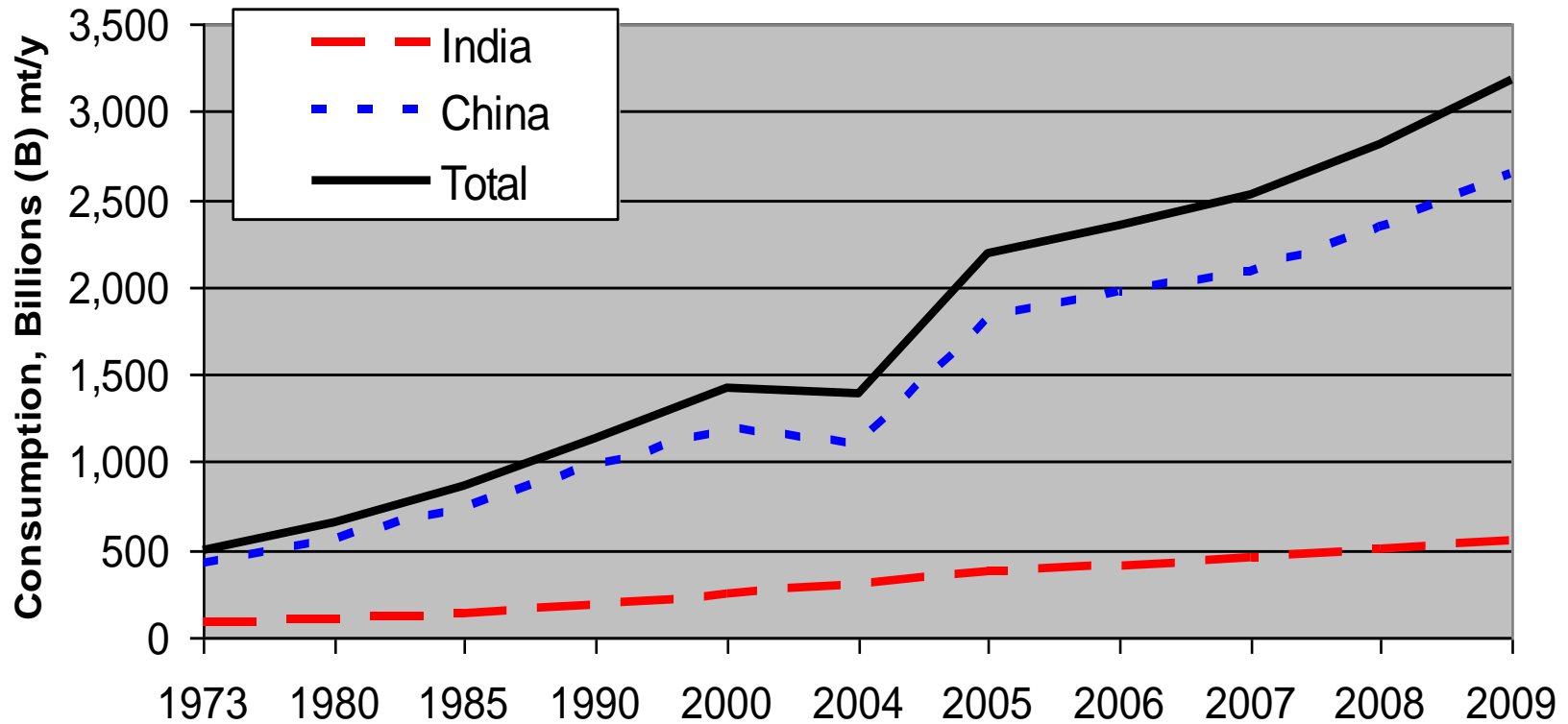


Coal Long Term Outlook

- **World steam coal production/consumption approaching 6 B mt/y**
- **More than half of the consumption is India and China**
- **Most goes to power generation**
- **Solar replacement very expensive, takes lots of land**



China and India Steam Coal Consumption, 1973-2009

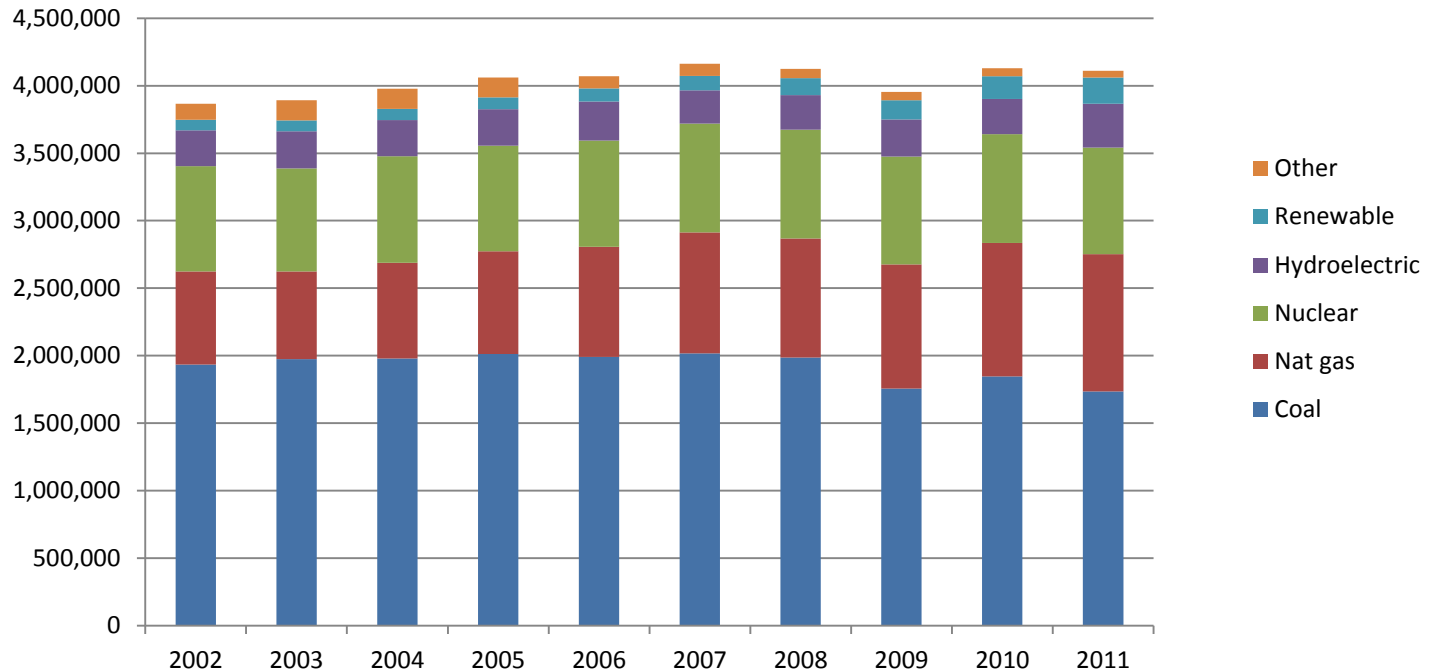




US Example

Reduce coal consumption by 10% from 2011

US Electricity Generation by Fuel type, GW-hr





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US Example

Reduce coal consumption by 10% from 2011;
Replace with Solar

	2011
Total US elec generation, GW hr	4,105,000
Electrical generation by coal, GW hr	1,734,000
10% Reduction of coal generation	173,400
Ranch solar Gw hr/sq mi	114.4
Ranch solar land required to make up the 10%, sq miles	1,515
Number of required solar ranches size of Los Angeles	3



Observations

- Hard to see if oil refining industry will collapse, even with GHG solutions
- Takes a lot of electric cars to drop the US coker margins to where pet coke won't be made
- Incremental electric power for cars likely to come from solar
- Hard to see if global coal industry will collapse
- Takes a lot of solar to reduce coal-fired power even by just 10%
- Solar costs more to build and operate than conventional coal and gas



Conclusions

- **Pet coke will be with us for a long time**
- **If serious about GHG in the US, all-electric vehicles and the solar ranches to support them will need to expand very quickly at great cost**
- **More likely US will see existing coal-fired power replaced with nat gas, and incentives for the consumer to buy GHG free cars, and to build solar plants**
- **India and China coal use will likely NOT follow the US pattern**



Yes, but...

What about diesel?

- Yes, trucks and buses can also be all electric, railroads can be electrified. Could add another 20% to solar required in US and further reduce LHS

What about jet fuel, fuel oil for ships

- Can't see how planes will use anything else, so no change to LHS
- Difficult to see alt fuels for ships



Yes, but...

What about renewables for power ? Won't that reduce the solar power required if we want to reduce GHG?

- Yes power from renewables reduce the solar required
- But, upon burning, renewables just yield the CO₂ they consumed when growing; no net CO₂ reduction
- Might be better than to grow more switchgrass to absorb CO₂ and **NOT** burn it



Yes, but

What about clean coal and coke IGCC (GHG free) for new power generation instead of solar ?

- Clean Coal debate: Can CO₂ really be recovered? Not much track record.
- IGCC on coal and coke still low operating factor (It's a reactor, not a boiler)
- Both require a home for the recovered CO₂



Yes, but...

What about retro fitting conventional coal/gas power plants to reduce GHG emissions ?

Requires:

- Refrigerating the stack gas to recover the CO₂
- N₂ removal from the combustion air to reduce stack gas load
- Still need to find a home for the CO₂

Enormous cap cost and reduction in efficiency



Yes, but

What about new technology to reduce GHG in power generation or as a direct car fuel:

- Fusion
- Plasma
- Alternate H₂ manufacturing
- ?????



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Fusion, Plasma, Alt H2, ???

