Amy Myers Jaffe
Executive Director
Energy and Sustainability
University of California - DAVIS

Peak Oil Demand Scenarios: Testing Sensitivities to New Technologies

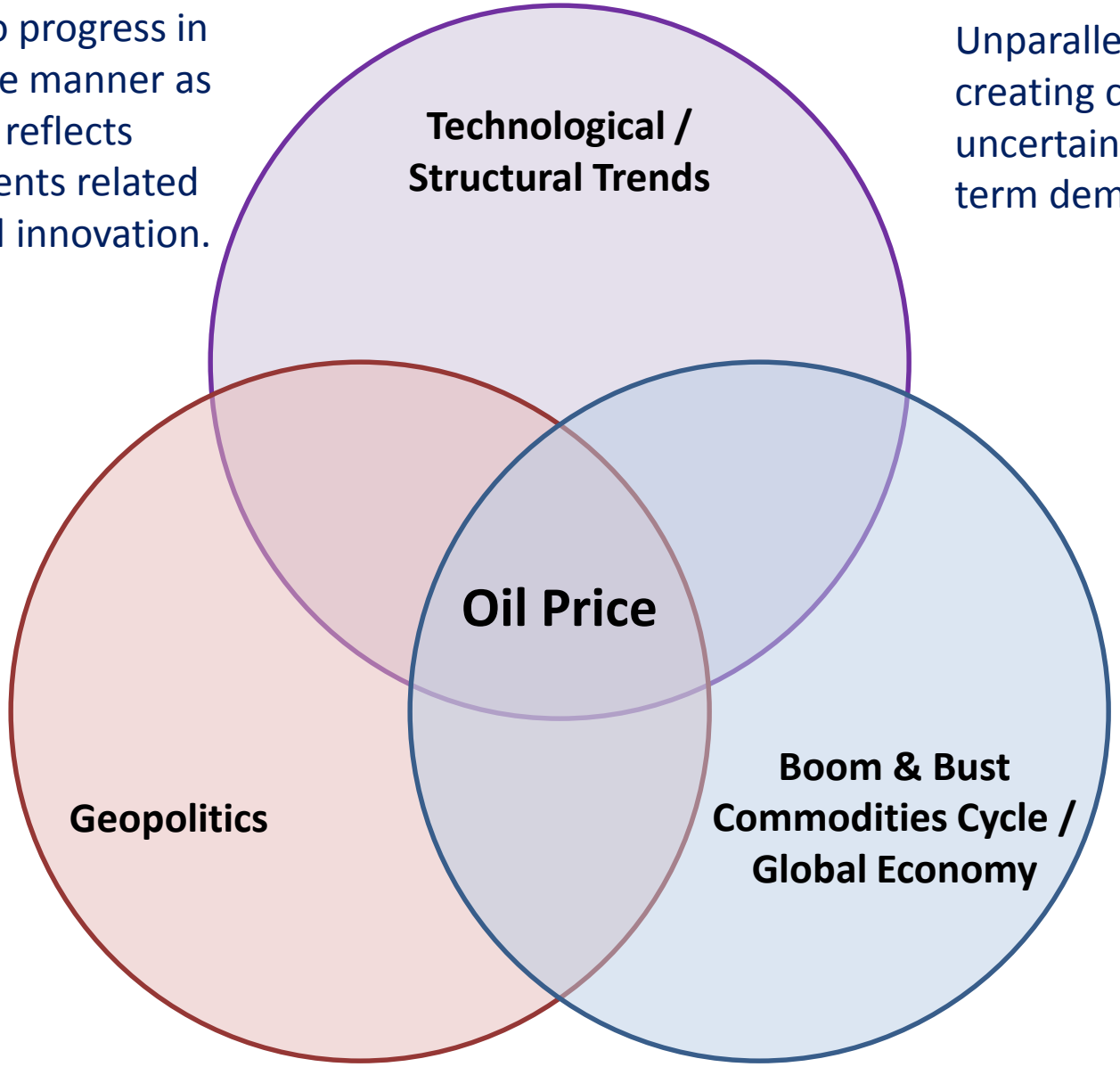
ITS UCDAVIS INSTITUTE OF TRANSPORTATION STUDIES

30 years of conventional wisdom is over now, forever New World Order: Take It Out of the Ground Now

- Since 1980s, conventional wisdom held that "**easy oil**" in non-OPEC would be depleted by 2010s and the world would be **increasingly reliant on OPEC oil**.
- OPEC responded to this view by taking a revenues oriented strategy in the 2000s. Gulf countries viewed reserves as increasing in value over time for "future generations."
- Technology innovation, Paris climate accords and US shale boom throws this future reserves scarcity model into question
- Uncertainty about long term demand outlook shifting strategic calculus of largest reserve holders
- OPEC Countries that have announced major capacity expansion plans: Kuwait, UAE, Iran, and Iraq
- Non-OPEC countries with major new finds (and/or rising production): Russia, Kazakhstan, Eastern Canada, Uganda (check), other Africa
- Majors no longer warehousing. Pressure to make every dollar spend efficient in a produce it now attitude re satellite extensions and deeper reserves

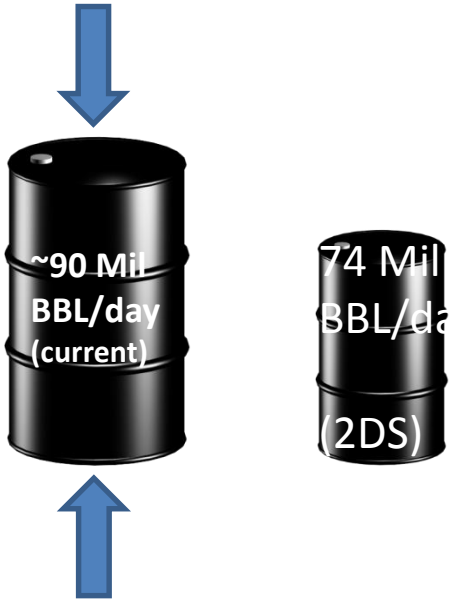
Cycle unlikely to progress in exactly the same manner as past cycles as it reflects structural elements related to technological innovation.

Unparalleled changes creating confusion and uncertainty about long term demand trends.



Forces Impacting Long Term Oil Demand: Old vs. New

"Superior" Technologies
Legislative and Tax Policy
Urbanization
Energy Efficiency (*energy per GDP declining*)
Millennials Reject Vehicle Ownership
Growth of Alternative Energy
Elimination of Fuel Subsidies



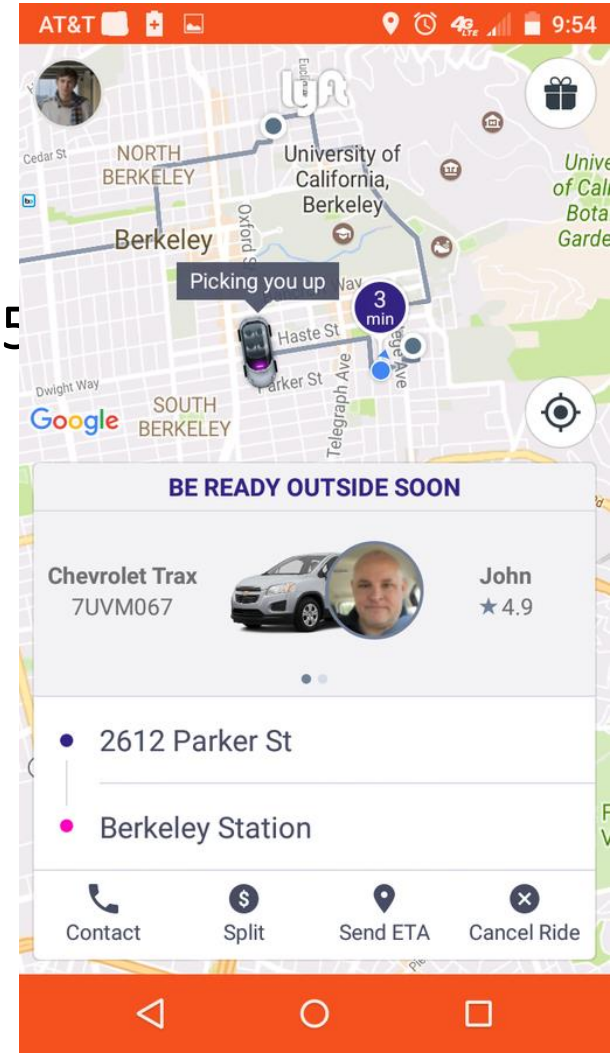
Population Growth
Emerging Economy Expansion
Expanding Global Middle Class

Three Revolutions in Passenger Transport

1. Streetcars (~1890)
2. Automobiles (~1910)
3. Airplanes (~1930)
4. Limited-access highways (1930s….195

<u>2010+</u>

1. **Vehicle electrification**
   - low carbon vehicles and fuels
2. **Real-time, shared mobility**
   - less vehicle use
3. **Vehicle automation (2025?)**
   - Uncertain impacts

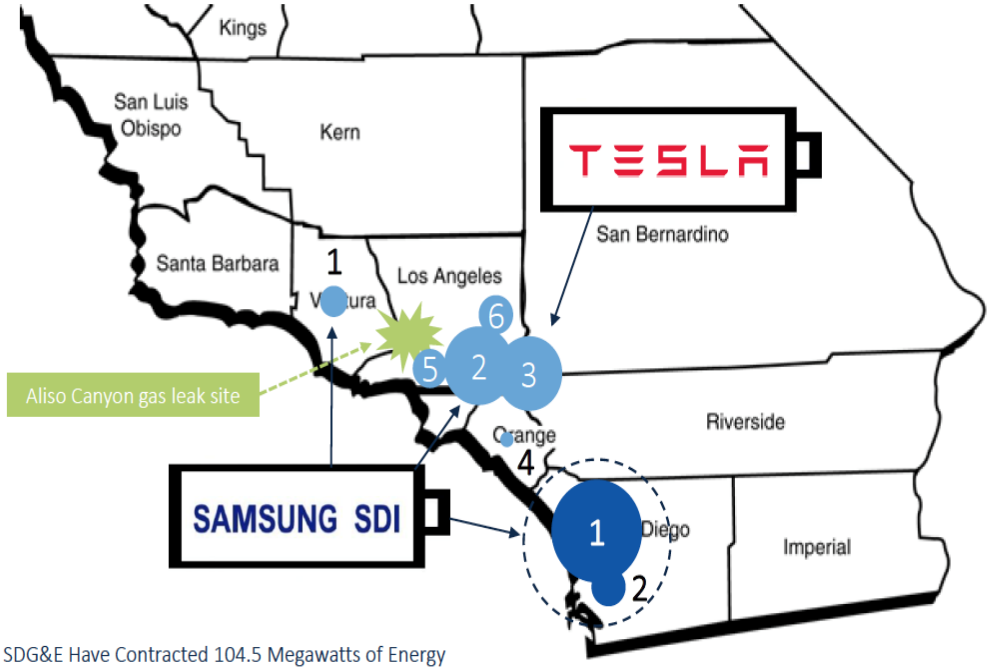


There are real drivers to technology revolution unrelated to climate policy

- National industrialization policies: Global cost reduction and technology innovation competition
- Urbanization
- Congestion!
- Cities – Sustainability and livability, pedestrian centers and urban road pricing policies
- Air pollution, air pollution, air pollution
- Optimized freight and other logistics-driven big data applications
- Rise in last mile delivery services
- Demographic trends in countries with declining populations
- Millennial behavior change

New Battery Storage Projects in California

Aliso Canyon Expedited Energy Storage Procurement Totals 104.5 Megawatts



SCE and SDG&E Have Contracted 104.5 Megawatts of Energy Storage As Part of Aliso Canyon Procurement

CA County Map Source: California Elections Website http://www.sos.ca.gov/elections/map/

Source: GTM Research

SCE Aliso Canyon Awarded Procurements

1. Western Grid Santa Paula, 5 MW/20 MWh
   On-line target Q1 2017
2. AltaGas-Greensmith Pomona, 20 MW/80 MWh
   On-line target Q4 2016
3. Tesla Ontario, 20 MW/80 MWh
   On-line target Q4 2016
4. Powin Energy Irvine, 2 MW/8 MWh
   On-line target Q1 2017
5. GE Center, 10 MW/4.3 MWh
   On-line target Q4 2016
6. GE Grapeland, 10 MW/4.3 MWh
   On-line target Q4 2016

SDG&E Aliso Canyon Awarded Procurements

1. AES Escondido 30 MW/120 MWh
   On-line target Q1 2017
2. AES El Cajon 7.5 MW/30 MWh
   On-line target Q1 2017

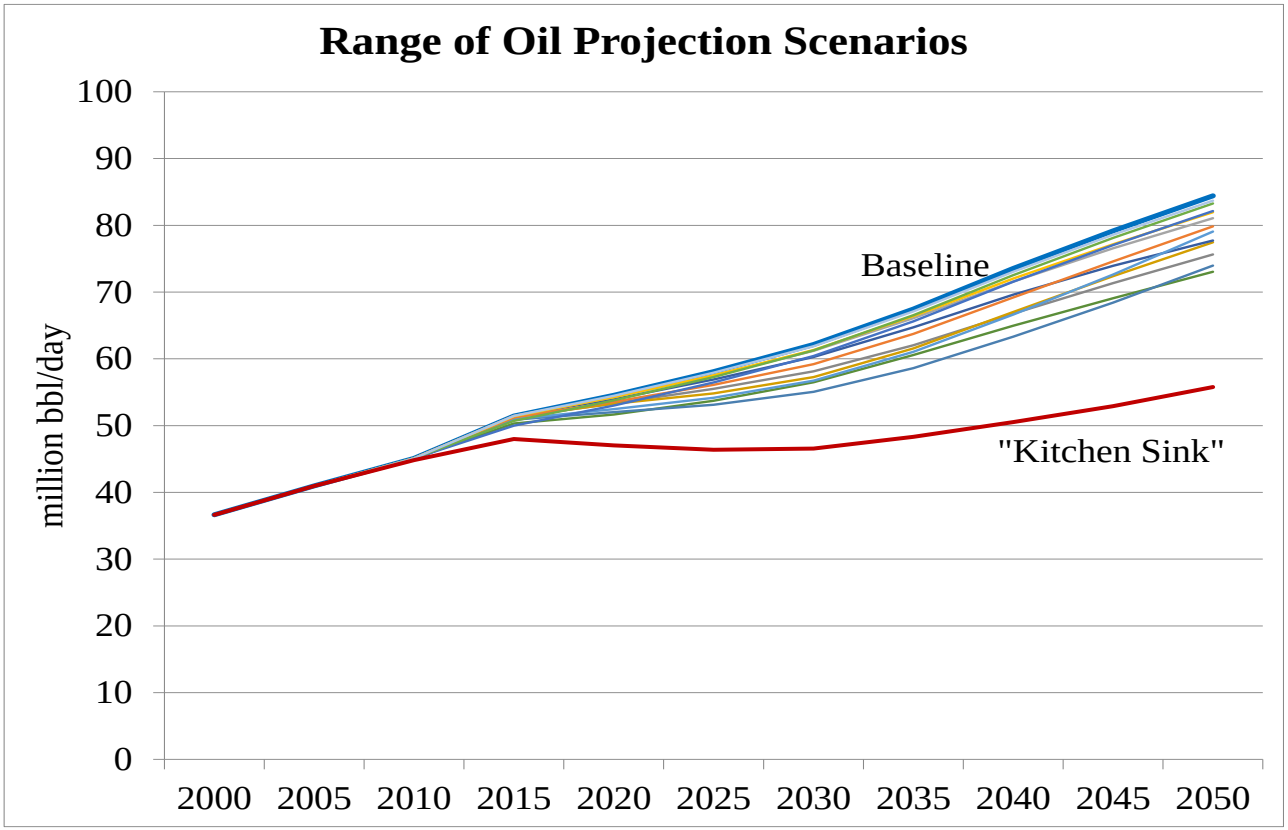
SCE Procurement	SDG&E Procurement
47 MW/4-hr. duration, 20 MW/25-min duration	37.5 MW/4-hr. duration
Multiple RFP winners	Single awardee
On-line 2016/2017	On-line 2017
New procurements ordered from CPUC	Procurements expedited from ongoing LCR program

GTM Research Based on SCE and SDG&E announcements and procurement websites

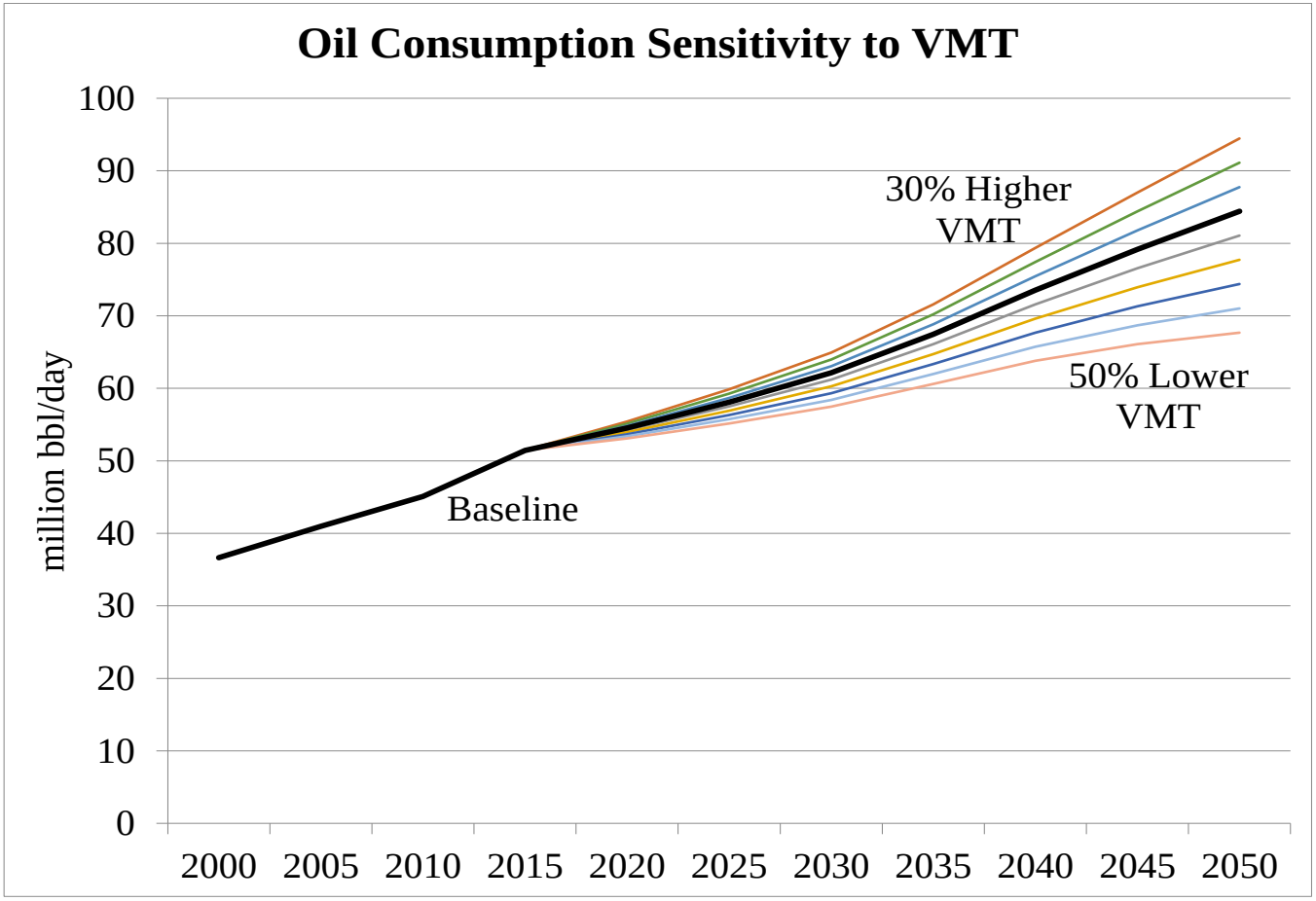
I get it, it is hard to eliminate oil demand, but “peak” oil demand no longer viewed as impossible for 2020s or 2030s

	2040	% change	Notes
IEA New Policy	103	Up 14%	Fossil fuels remain 75%
IEA 2 Degrees	74.1	Down 19 %	
Statoil Renewal	79	Down 15%	EV growth = Oil less than 40% of transport
50% Battery cost decline scenario	74.6	Down 19%	EVs at close to 20% of all new car sales by 2030

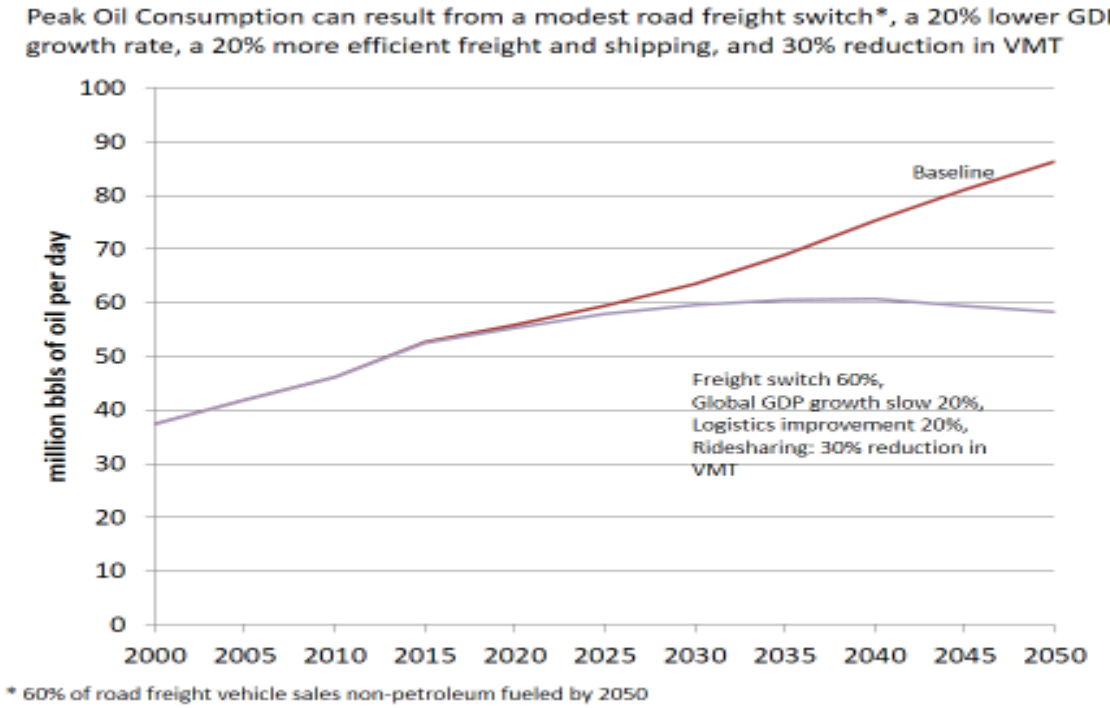
Just Technology: Scenario Outcomes per Inputs



Potential impact of increased shared mobility/autonomous vehicles: Oil consumption highly sensitive to changes in VMT



What Does It Take to Peak Oil Consumption in Transport by 2040? A Technology-Oriented Scenario

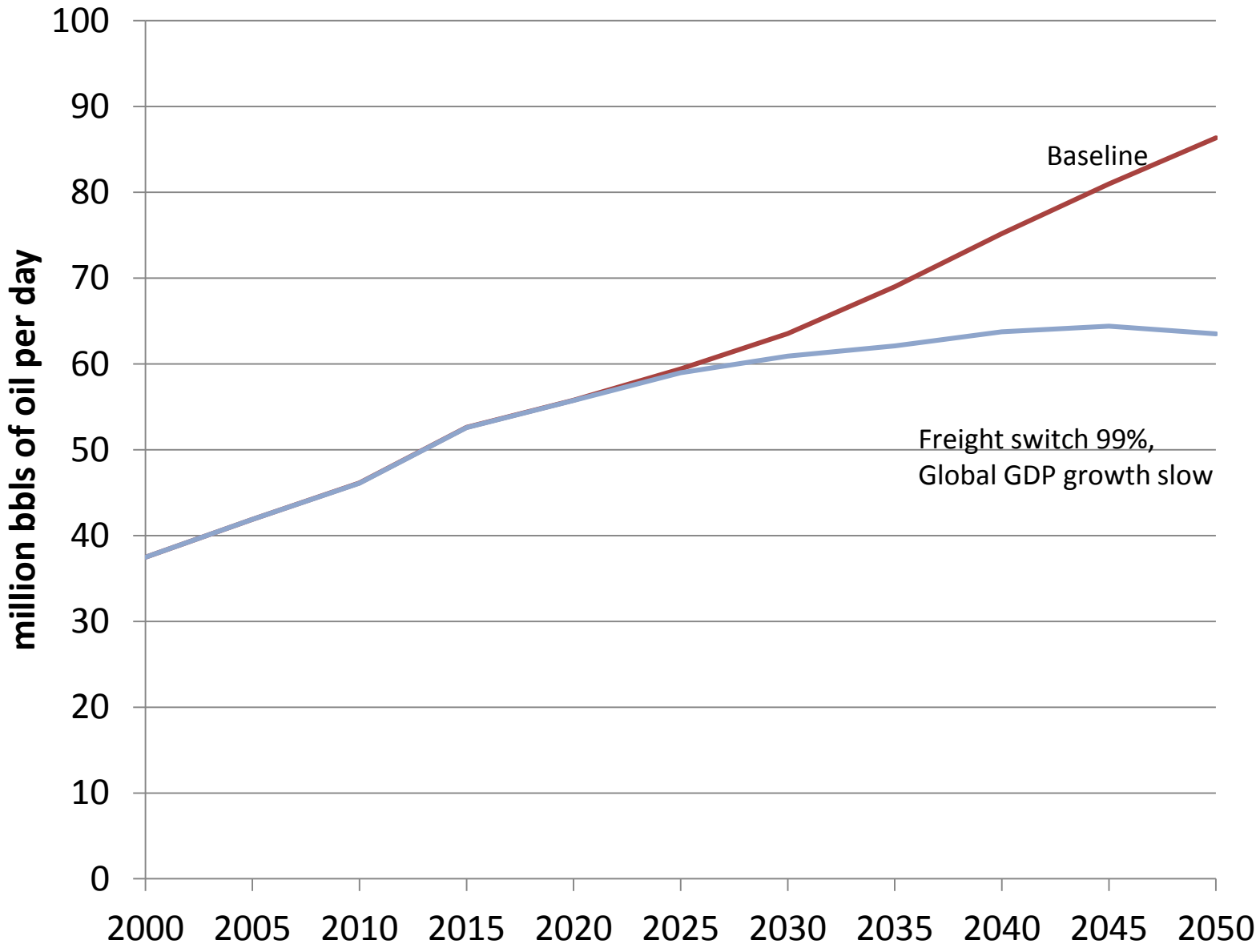


Source: UC Davis analysis, IEA Transport Model

- **At least 60% of on-road trucking switches to alternative fuels**
- **20% Logistics improvement via digitization**
- **Ridesharing brings about a 30% reduction in VMT**

(Scenario assumes a 20% slower growth in GDP than IEA BAU but adds no climate-oriented policies)

Peak Oil Consumption can result from a rapid road freight switch*, and a 20% lower GDP growth rate



* 99% of road freight vehicle sales non-petroleum fueled by 2050

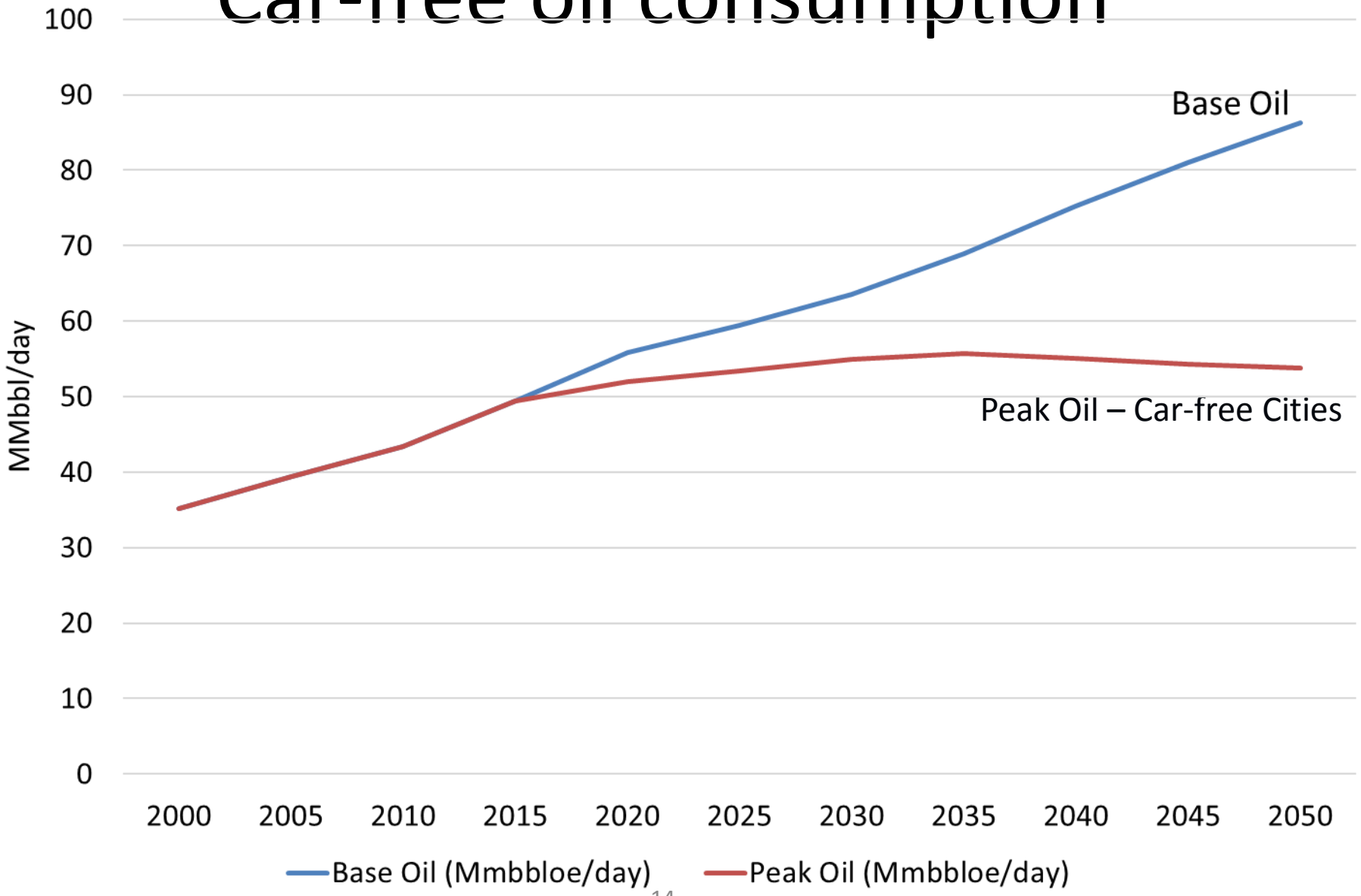
Peak Oil Demand Scenarios – Car-free Urban Areas

Car-free urban areas

- Car stock is reduced proportional to the percentage of inhbitants living in urban centers
- MoMo regions are split into early, middle, and late adopters of the car-free city
- Phasing out of PLDV stock could also be interpreted as a ban on ICE in urban areas
- Literature on car-free urban centers is abundant, but I believe the most powerful documentation to support this scenario is the comprehensive list of car free urban areas in the world maintained by wiki:

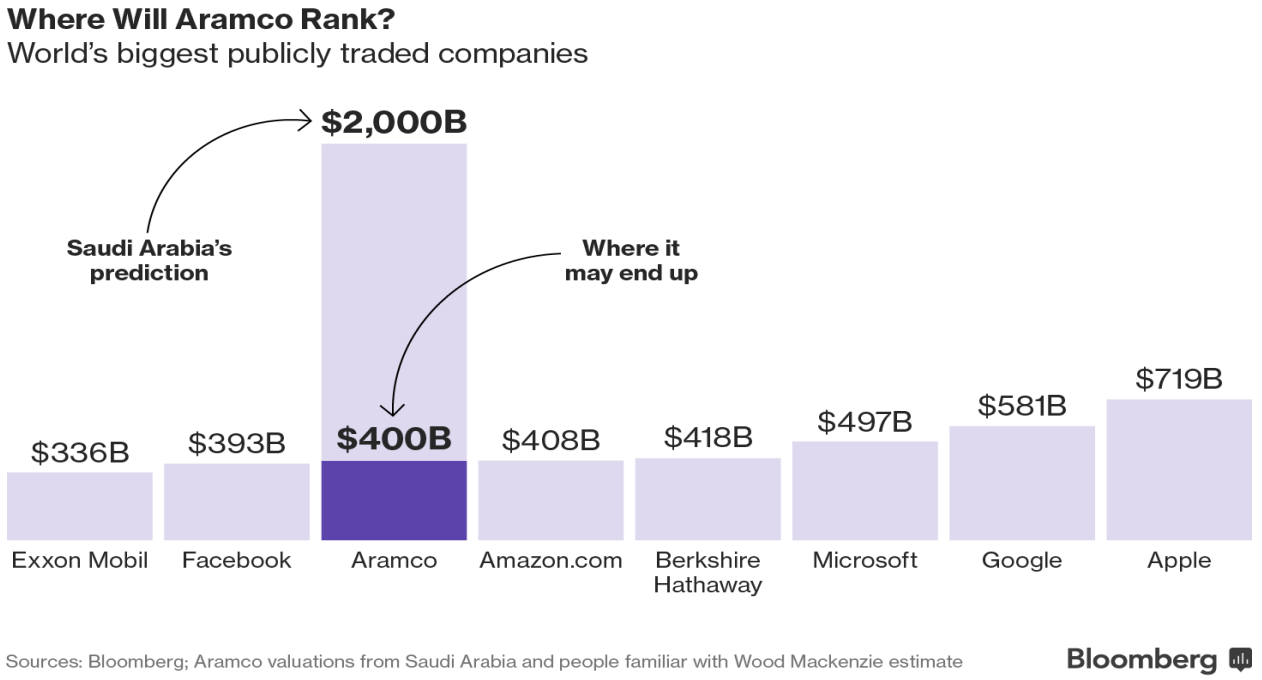
  https://en.wikipedia.org/wiki/List_of_car-free_places

Car-free oil consumption



The Valuation of Saudi Aramco May Be the Single Biggest Defining Event in Oil This Decade

Coupled with de-booking of 4.8 billion boe of EOM's reserves, including 3.5 billion barrel Kearl oil sands (equivalent to losing size equivalent of Anadarko, combined with Marathon Oil and Hess), markets may be poised to rethink its ideas about long term value of "warehoused" oil reserves



Appendix – Demand Scenarios

Key Indicators of the High Growth Worldview

- Population growth > 9 billion by 2040 (*problem, increasing doubts on number, wealth effect*)
- 5 billion people reach the Middle Class by 2030, up from 2 billion in 2014, according to Brookings Institution study
- Wealthier populations desire personal automobiles, world car stocks hit 1.7 billion cars, up from 825 million in 2010 (*problem of congestion effect, shared mobility*)
- Economic growth driven by rising Asia, Africa, GDP per capita doubles in Brazil, Mexico, South Africa, Nigeria, Turkey, Iran, Thailand, Indonesia, other ASEAN *(forecast problem of compounding vs convergence)*
- Lower oil prices stimulate purchases of larger vehicles and more travel, autonomous vehicles increase VMT (*what if opposite through efficiency*)
- Strong global GDP growth (> 2% per annum) leads to increased energy demand, especially higher commercial transport, increasing difficulties for countries to meet COP 21 Paris commitments (*what if freight efficiency, alt fuel in trucks shaves demand*)

Additional Key Indicators – High Growth Scenario

- China exports excess capacity to build massive One Road- One Belt network
- Consumer apps take off in China, India, ASEAN, adding to local consumer oriented economic growth and added freight demand
- Low oil prices stimulate purchases of larger vehicles in US and more travel, autonomous vehicles increase VMT
- Increased foreign investment flocks to Africa

Key Indicators – 2 Degrees Scenario

- Multi-national corporations develop climate friendly capital strategies
- Carbon pricing expands to most major economies
- Governments increase regulation of energy efficiency in buildings, automobiles, freight
- Acceleration in adoption of renewable energy and advanced vehicles
- Mission Innovation succeeds to bring increased R & D budgets in major economies

Key Indicators – Battery Breakthrough Scenario

- Policies to reduce air pollution and GHG emissions increase penetration of disruptive technologies
- Share of electric vehicles increases to over 15 to 20% (over 5% of all new car sales)
- 50% reduction or more in EV battery costs by 2025
- 50% reduction in the cost of utility scale solar power (no longer needs subsidies) by 2025
- 50% reduction in stationary electricity storage costs by 2025
- Mandated policies like US Clean Power Plan and Chinese Advanced vehicles plan move forward quickly
- Technology advances in grid integration of wind and solar
-

ITS-Davis Slate of Scenario Inputs

Projected Oil Consumption (million bbl/day)												
	2000	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**% Reduction Relative to Baseline 2050**
Baseline	36.6	41.0	45.1	51.4	54.5	58.1	62.1	67.5	73.5	79.2	84.4	
25% Reduced Vehicle Saturation	36.6	41.0	45.1	50.3	51.7	53.7	56.5	60.6	65.0	69.1	73.0	13.48%
Global Growth Reduction 20%	36.6	41.0	45.1	50.9	52.0	53.1	55.1	58.6	63.3	68.4	74.0	12.38%
No China-India Growth	36.6	41.0	45.1	51.2	53.3	55.5	58.1	62.0	66.8	71.3	75.6	10.38%
20% Freight Improvement	36.6	41.0	45.1	51.3	53.3	54.8	57.3	61.6	67.0	72.4	77.5	8.23%
20% Lower VMT	36.6	41.0	45.1	51.4	54.0	56.9	60.3	64.7	69.6	73.9	77.7	7.93%
Global Growth Reduction 10%	36.6	41.0	45.1	51.0	52.5	54.2	56.7	61.1	66.6	72.6	79.1	6.34%
No China Growth	36.6	41.0	45.1	51.2	53.6	56.1	59.2	63.7	69.2	74.6	79.8	5.41%
10% Lower VMT	36.6	41.0	45.1	51.4	54.2	57.5	61.2	66.1	71.6	76.5	81.1	3.96%
10% Freight Improvement	36.6	41.0	45.1	51.4	54.3	57.5	61.3	66.4	72.0	77.2	82.0	2.91%
20% Air Efficiency Improvement	36.6	41.0	45.1	50.0	53.0	56.5	60.4	65.6	71.5	77.0	82.1	2.70%
10% Air Efficiency Improvement	36.6	41.0	45.1	50.7	53.8	57.3	61.3	66.5	72.5	78.1	83.3	1.35%
Shipping Improvement	36.6	41.0	45.1	51.4	54.5	57.9	61.9	67.1	73.0	78.6	83.7	0.85%
All Above (Kitchen Sink)	36.6	41.0	44.8	48.0	47.0	46.4	46.6	48.3	50.5	52.9	55.8	33.91%

Rough guide to three revolution scenarios as they apply to climate policy

	Automation	Electrification	Shared Vehicles	Urban Planning/ Pricing/TDM Policies	Aligned with 1.5 Degree Scenario
Business as usual, Limited Intervention	Low	Low	Low	Low	No
1R Automation only	HIGH	Low	Low	Low	No
2R With high Electrification	HIGH	HIGH	Low	Low	Maybe
3R With high shared mobility, transit, walking/cycling	HIGH	HIGH	HIGH	HIGH	YES

Five Country/region analysis – basic comparison

Country	Income level	City forms	Vehicles	Policies
USA	High	Sprawl	SOV, SUV-dominated	Pro-car, pro-EV
OECD Europe	High	Dense	Mixed modes, excellent transit	Anti-car, pro-EV/NMT
China	Moderate	Dense but sprawling	Mixed modes but cars rising; concern rising	Car stock management, pro-EV
India	Low	Dense but sprawling	Mode fragmentation, intense congestion	Weak policy structure; EV signal weak
Brazil	Moderate	Mixed	Mixed modes, medium quality transit	Unclear priorities