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Road Transport Energy Demand and CO_2 Emissions in APEC Economies through 2040

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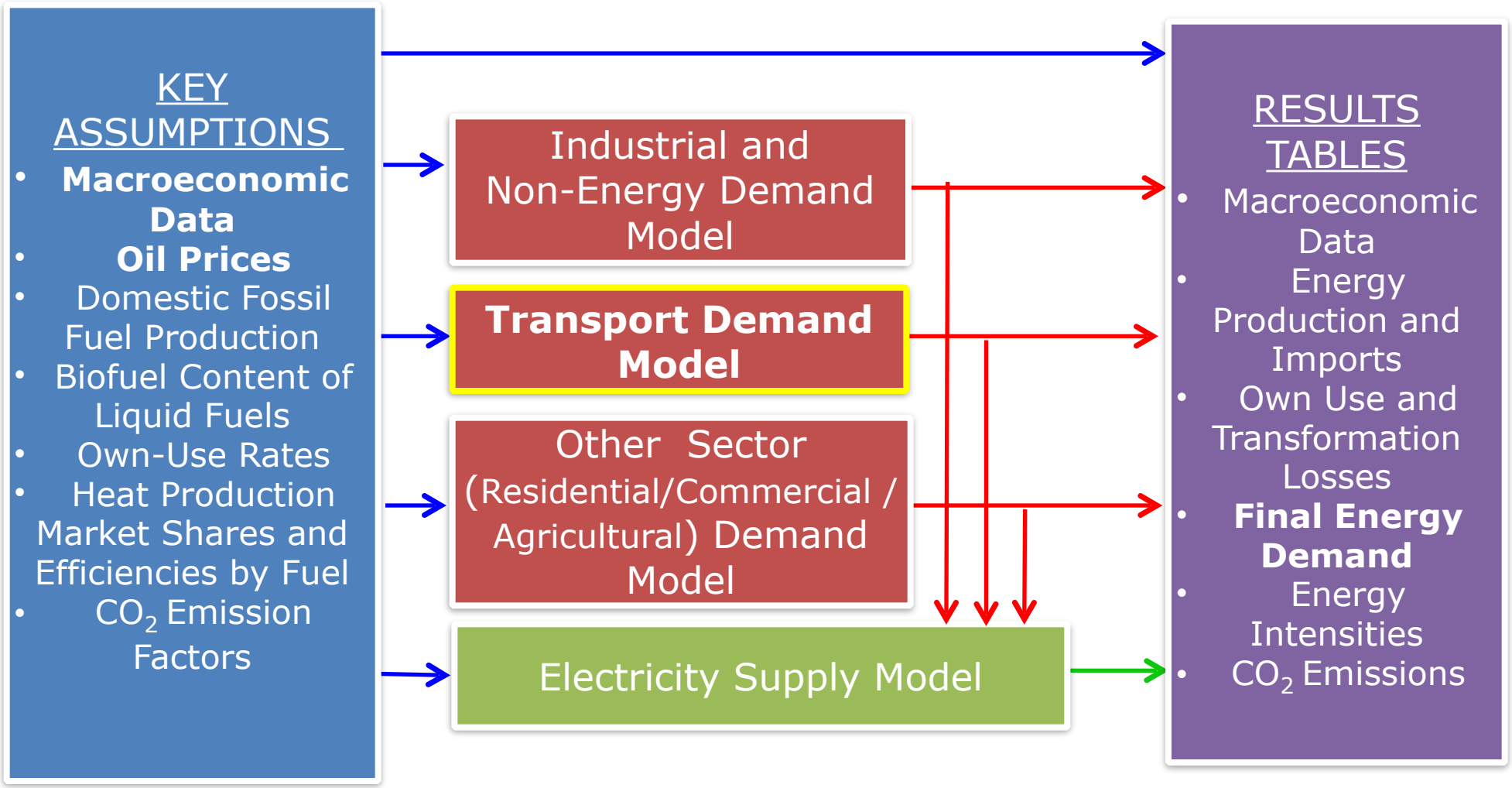
Outline of the presentation

- Introduction
- Methodology
- Results & Discussion
- Conclusion remarks

APEC's Members

"This map is for illustrative purposes and is without prejudice to the status of or sovereignty over any territory covered by this map."

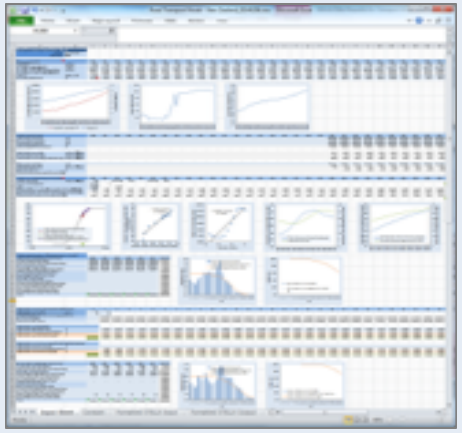
APERC's Outlook Model Structure



Transport Sector Modelling Techniques

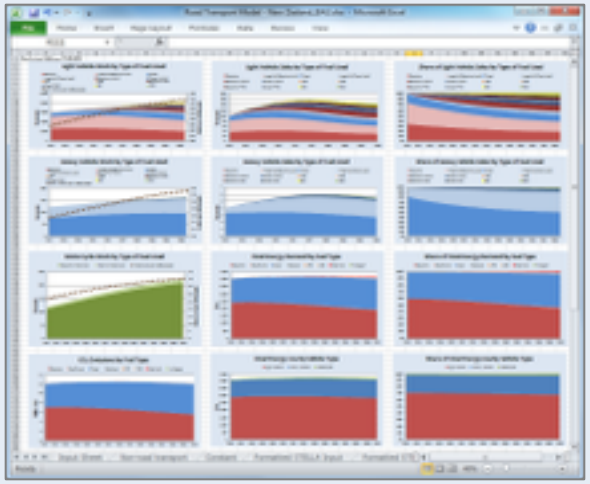
Transport sub-sector	Sub-mode/ vehicle class	APEC Energy Demand in 2011 (Mtoe)	(Percent)	Model
Domestic Road Transport	*- Light and Heavy vehicles* *- Motorcycles*	*1,053*	*73%*	*Bottom-up (Fleet Model)*
Domestic Non-Road Transport	*- Rail* *- Pipeline* *- Water* *- Air*	*37* *53* *33* *80*	*3%* *4%* *2%* *6%*	*Top-down (Econometric Model)*
International Non-Road Transport	*- Maritime* *- Aviation*	*109* *78*	*8%* *5%*	*Top-down (Econometric Model)*

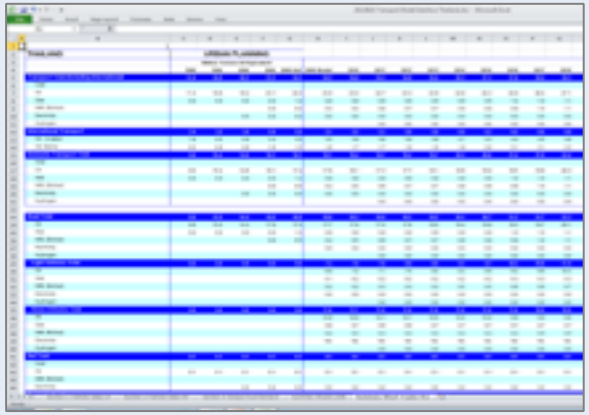
APERC's Vehicle Fleet Model



- **Macroeconomic data**
  - ✓ GDP & Population
  - ✓ Crude oil price
  - ✓ Urbanisation
- **Vehicle data**
  - ✓ Vehicle population
  - ✓ Vehicle age distribution
  - ✓ Vehicle sales
  - ✓ Vehicle fuel economy
  - ✓ Vehicle travel distance
- **Energy data**
  - ✓ Retail fuel prices
  - ✓ Blend ratio of biofuel
  - ✓ IEA road energy use

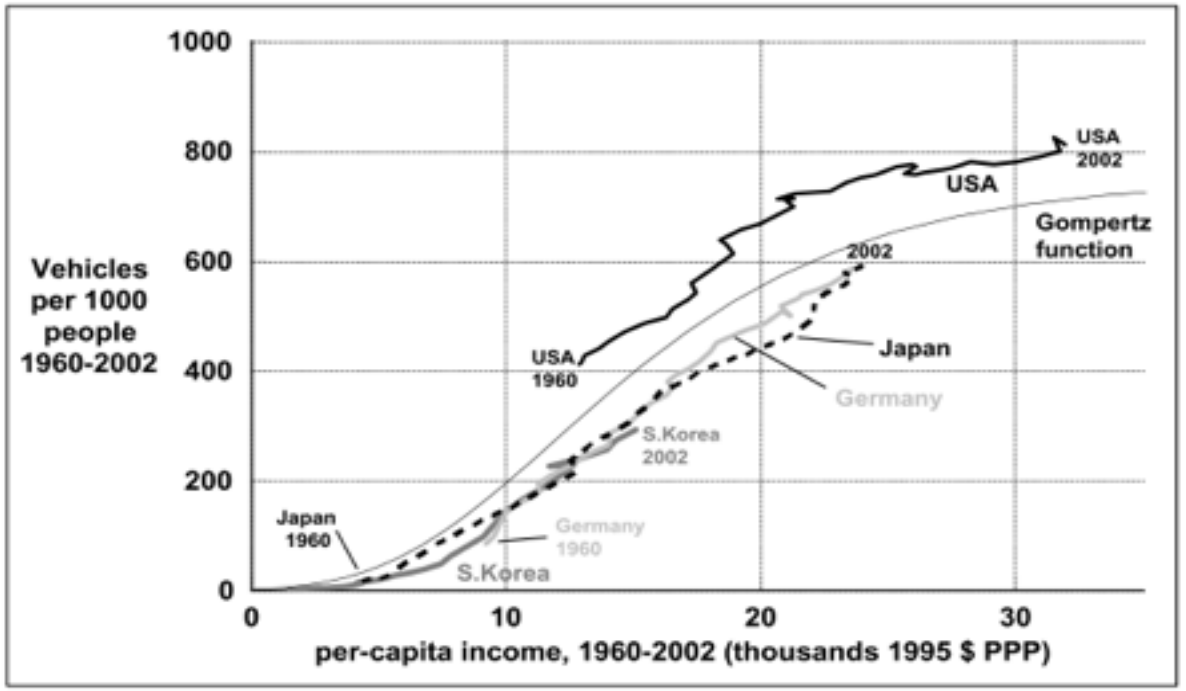
- **Vehicle ownership model** ***-> vehicle stock***
  (GDP per capita, vehicle saturation, total vehicle population, income elasticity, urban density)
- **Vehicle stock turnover model** ***-> vehicle sales and vehicle retirement***
  (vehicle population by type and vehicle distribution by age)
- **Vehicle consumer choice model** ***-> share of vehicle technologies***
  (fuel cost, purchase prices, driving range, refueling infrastructure, etc..)
- **Vehicle travel model** ***-> travel distance***
  (fuel cost, income, vehicle ownership, efficiency improvement, urban density)





Vehicle Ownership Model – Gompertz Function

$$V_t = \gamma e^{\alpha e^{\beta GDP_t}}$$



V_t = Vehicle population

γ = saturation of vehicle ownership

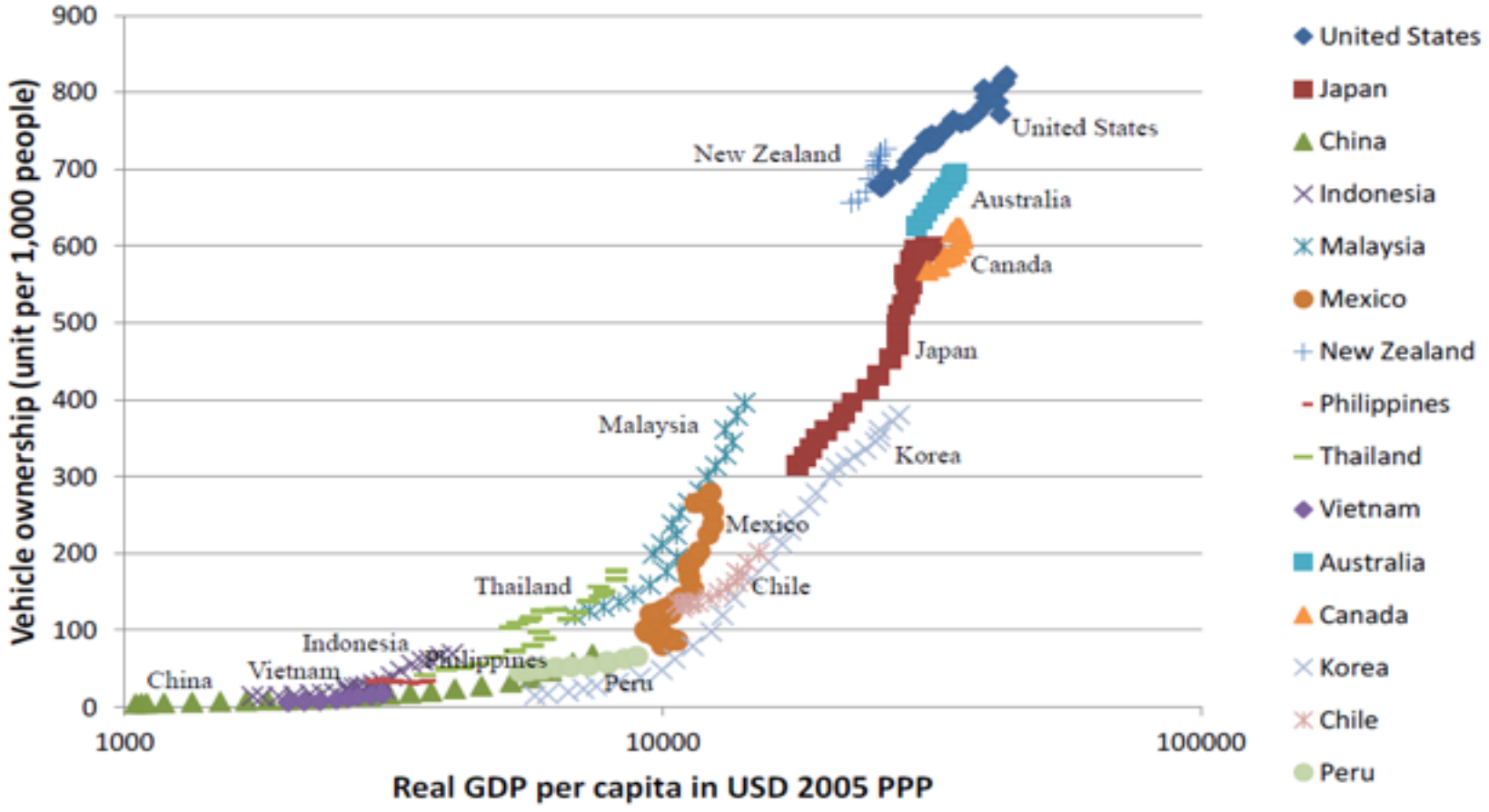
α = shape coefficient

β = rate coefficient

GDP_t = GDP (real) PPP

*Source - Dargay J, Gately D and Sommer M (2007) Vehicle Ownership and Income Growth, Worldwide: 1960-2030.

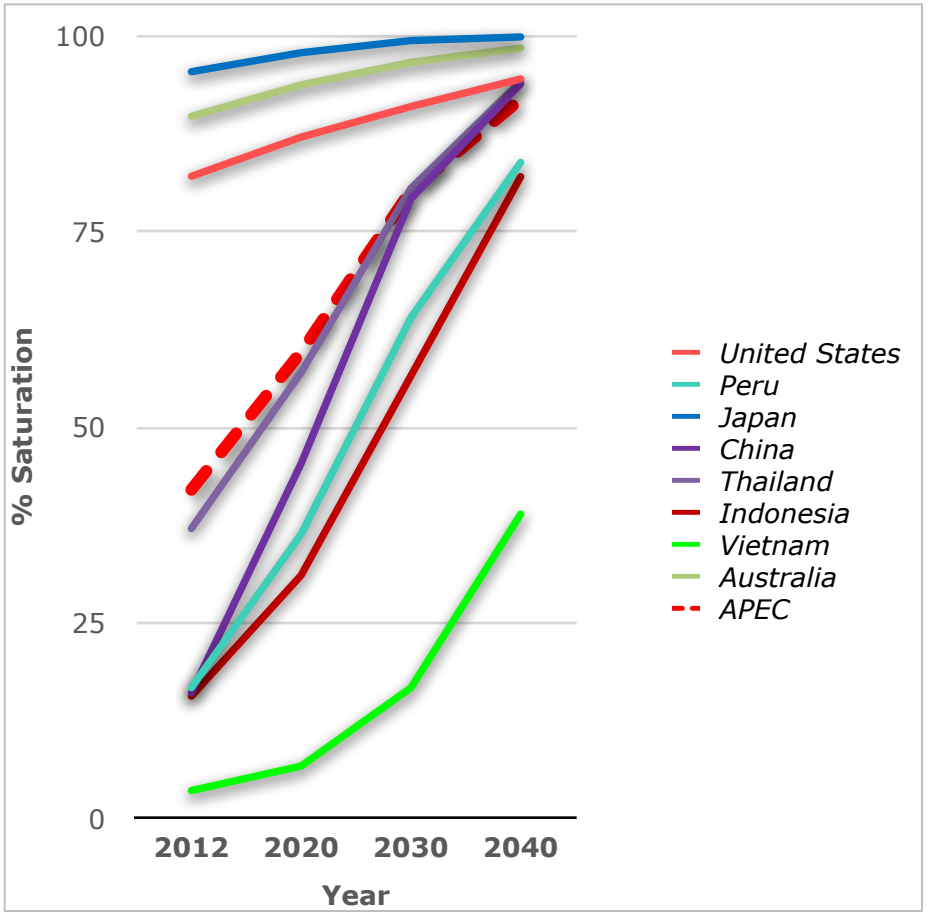
Historical Vehicle Ownership Curve of APEC Economies



(Source: APERC, 2015)

Forecasted Vehicle Ownerships by Economy

	Vehicle per 1,000 Population				Saturation
	2012	2020	2030	2040	
Canada	640	679	709	737	780
United States	771	820	834	846	870
Mexico	288	394	462	482	488
Peru	70	153	269	352	420
Chile	215	306	382	425	503
Russia	311	385	456	511	600
Korea	380	436	459	467	472
Japan	598	613	623	626	627
China	80	226	395	468	499
Chinese Taipei	309	313	316	317	320
Hong Kong	85	86	86	86	92
Singapore	157	165	167	168	170
Thailand	190	293	414	484	514
Malaysia	413	516	584	608	617
Indonesia	74	146	266	385	470
Philippines	34	70	177	308	410
Vietnam	16	31	77	179	460
Brunei Darussalam	357	418	418	419	420
Papua New Guinea	11	20	50	119	500
Australia	700	731	753	767	780
New Zealand	705	740	759	772	780
APEC	232	329	442	507	551



(Source: APERC's estimate)

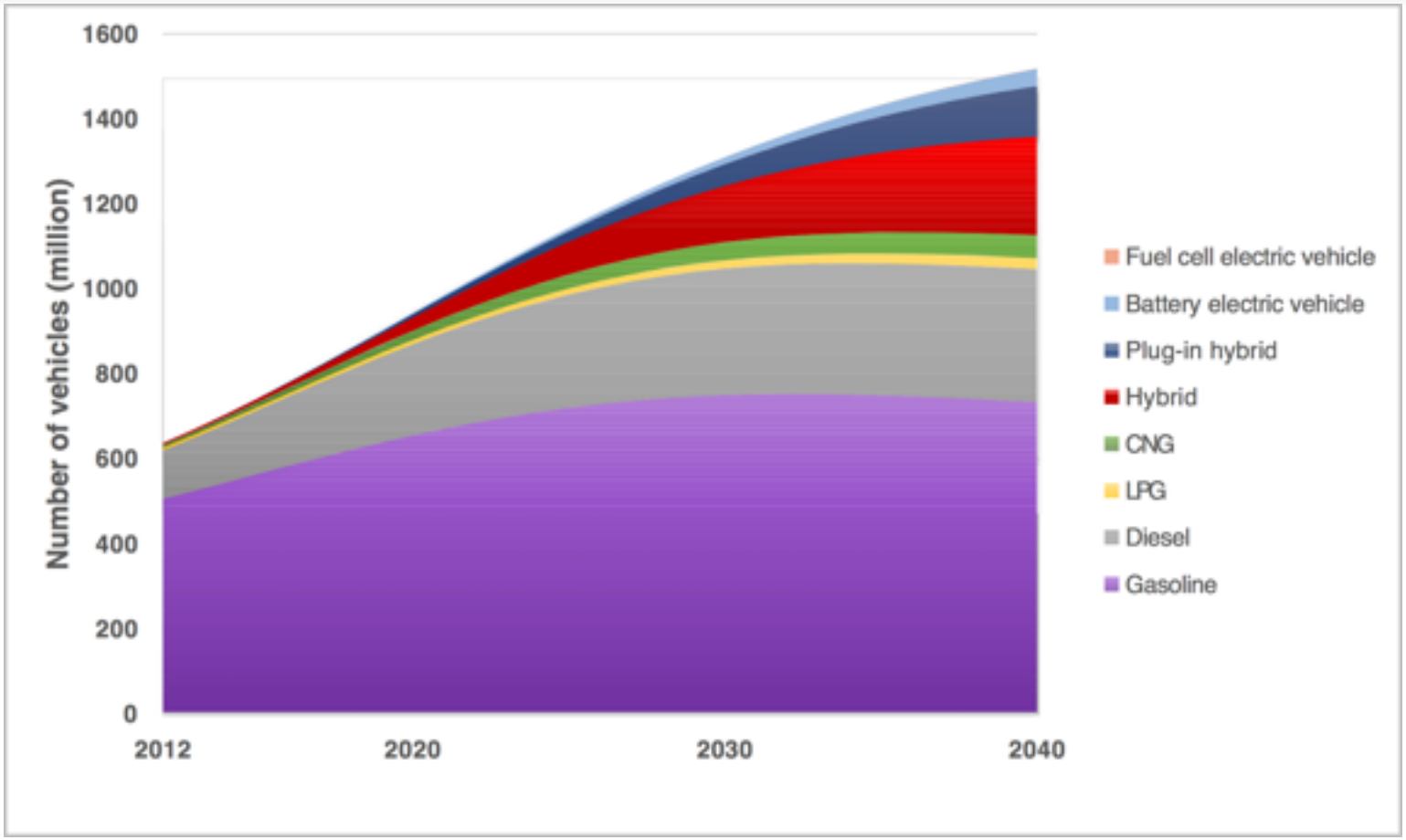
Vehicle Stock by Region

	Vehicle Stock (million)				% CAGR (2012-2040)	Additional Vehicles (2012-2040)	% Share
	2012	2020	2030	2040			
China	106	313	551	640	6.6%	533	60.5%
US	253	274	300	323	0.9%	69	7.9%
Russia	45	54	62	67	1.4%	22	2.5%
Other NE Asia	102	106	107	103	0.0%	1	0.1%
Other Americas	61	85	107	120	2.5%	60	6.7%
Oceania	19	22	27	31	1.8%	12	1.4%
South East Asia	50	88	157	235	5.7%	185	21.0%
APEC	637	943	1,310	1,519	3.2%	882	100%

(Source: APERC Analysis)

APEC to add nearly 900 million vehicles by 2040, nearly triple current levels. China and SEA account for more than 80% of this increase

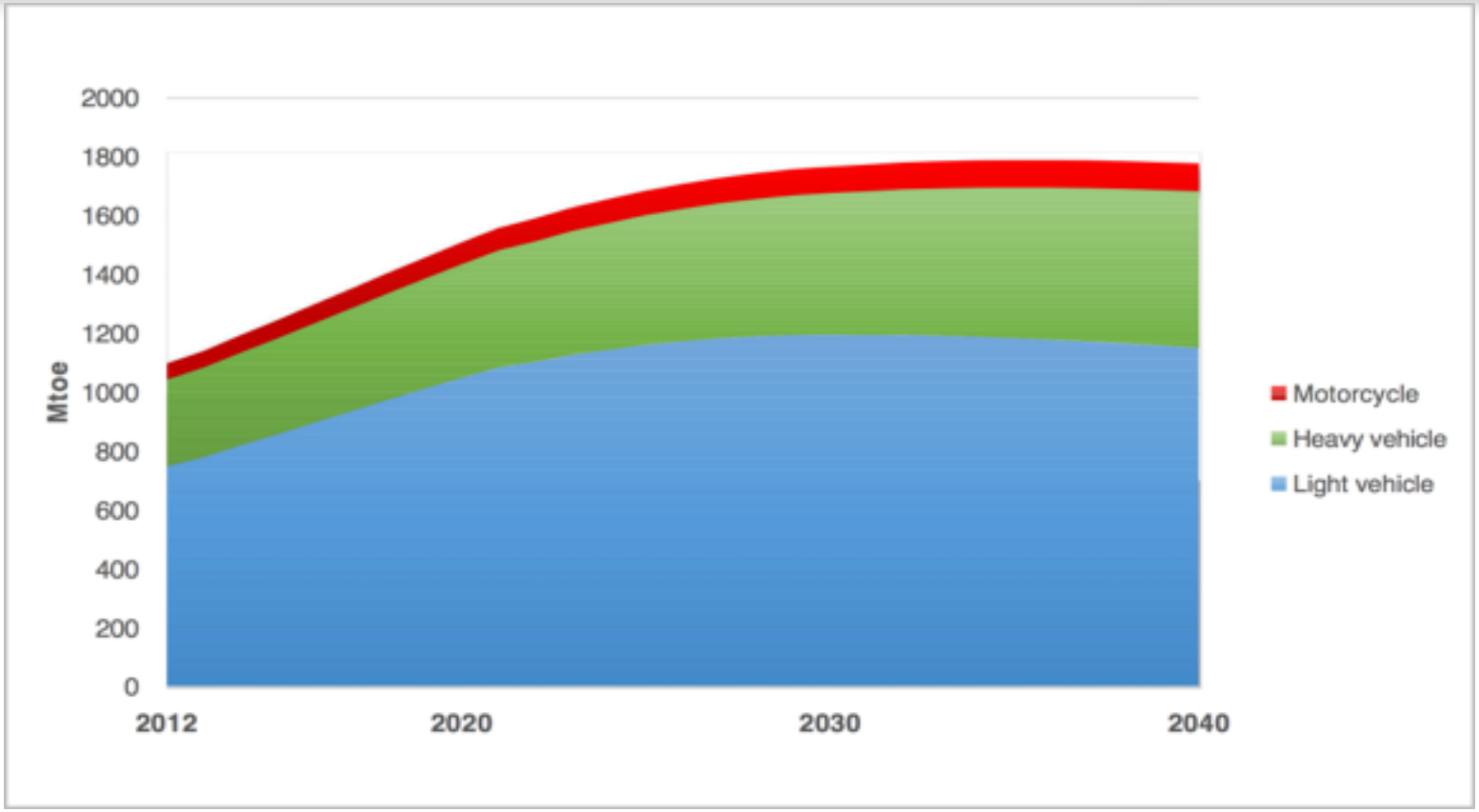
Vehicle Stock by Technology



(Source: APERC Analysis)

Advanced vehicles are slowly introduced, but conventional cars continue to dominate.

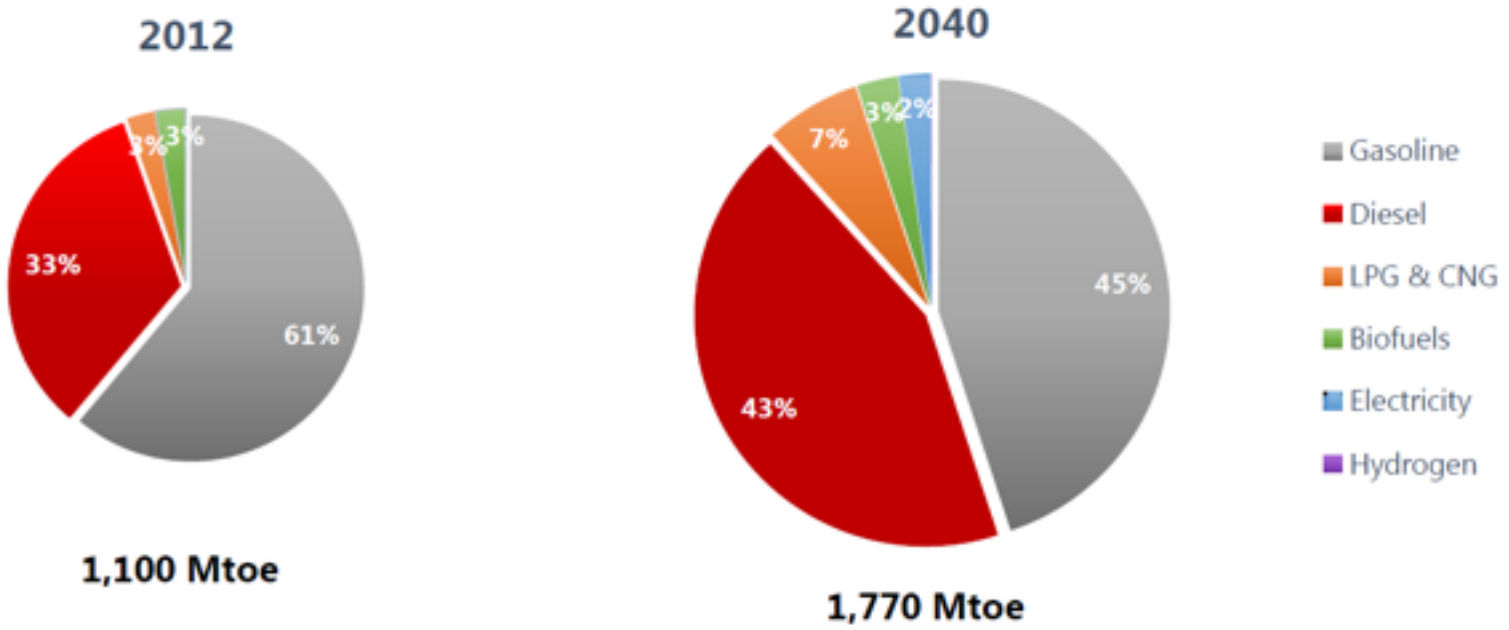
Road Transport Energy Demand



(Source: APERC Analysis)

Light duty vehicles represent two-thirds of road energy consumption, peaking in 2030 thanks to improvements in fuel economy. Heavy vehicles show the largest growth rates as demand for materials continue to rise.

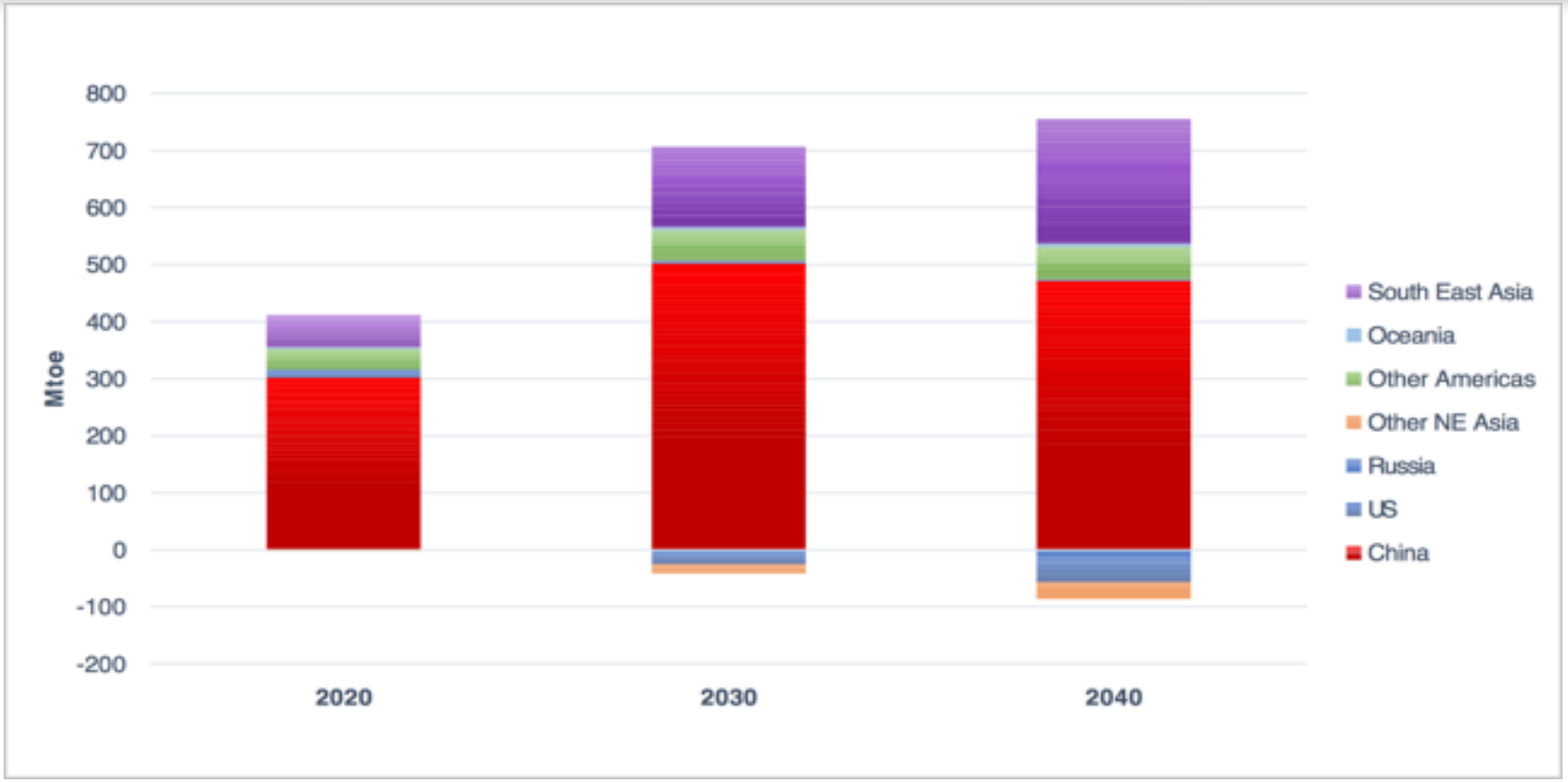
Fuel Use in Road Transport



(Source: APERC Analysis)

Oil remains the fuel of choice in the road transport sector

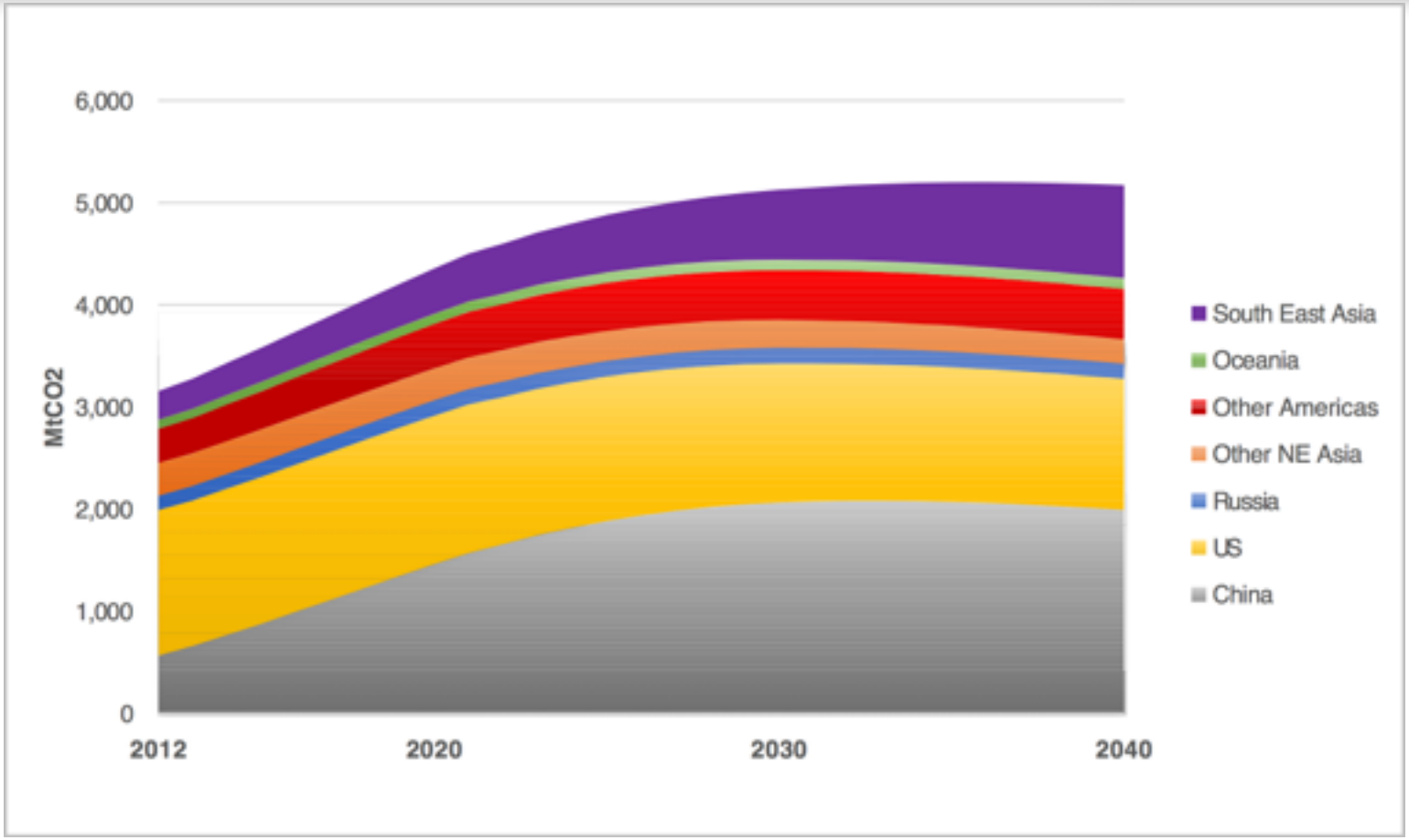
Regional Changes in Road Transport Energy Demand



(Source: APERC Analysis)

Transport energy demand rises sharply in China and South East Asia, while declining trends are seen in US, Russia and Other North East Asia thanks to slowing economic growth and tighter fuel efficiency

CO_2 Emissions from Road Transport by Region



(Source: APERC Analysis)

Concluding Remarks

- More than 80% of new vehicles added in APEC are in China and South East Asia. Fuel efficiency an urgent priority.
- Advanced vehicles are slowly introduced. Faster penetration is needed.
- Heavy vehicles will be more significant share of energy demand. Fuel economy standards for heavy vehicles and mode shift to high efficient modes are important.
- Transport sector still relies very much on fossil oil. Development of alternative fuels is needed more efforts to reduce CO2 emissions.

Thank you

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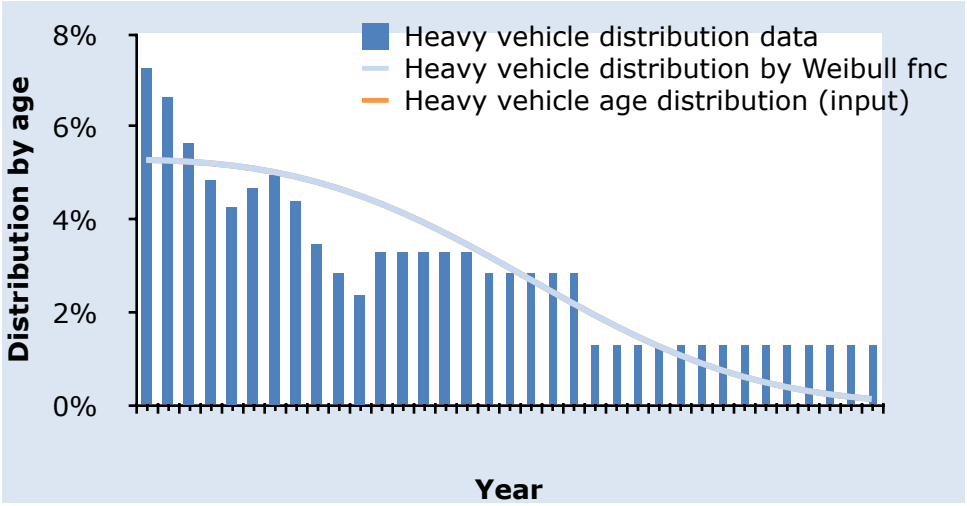
Appendix

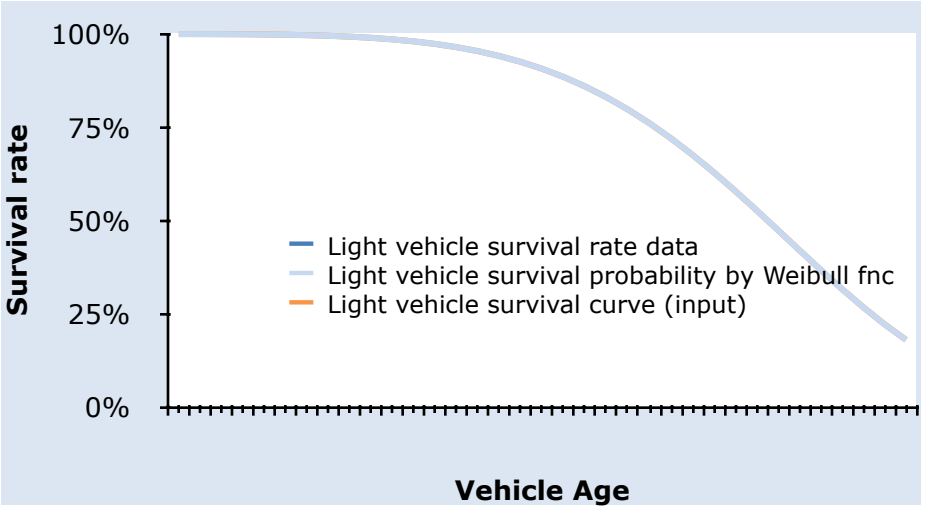
Vehicle Stock Turnover Model

$$Vehicle\ Sales_{t} = Expected\ Stock_{t} - (Vehicle\ Stock_{t-1} - Vehicle\ Retirement)$$

Surviving Stock



Vehicle distribution by age



Vehicle survival curve

Vehicle Consumer Choice Model

$$\text{Market Share (S)} = \frac{e^{(\beta_{FC}U_{FC}+\beta_{PP}U_{PP}+\beta_{DR}U_{DR}+\beta_{CMDD}U_{CMDD}+\beta_{PLDD}U_{PLDD})}}{\sum_i e^{(\beta_{FC}U_{FC}+\beta_{PP}U_{PP}+\beta_{DR}U_{DR}+\beta_{CMDD}U_{CMDD}+\beta_{PLDD}U_{PLDD})}}$$

β = vehicle choice coefficient
U = utility coefficient
i = vehicle technology
Note: Fuel cost (FC)
Purchase price (PP)
Driving radius (DR)
Convenient medium distance destinations (CMDD)
Possible long distance destinations (PLDD)

Type of Vehicle Technology

Powertrain Technology	Fuel Type
Internal Combustion Engine (ICE)	***Gasoline Diesel LPG CNG***
Hybrid Electric Vehicles (HEV)	***Gasoline/Diesel***
Plug-in Hybrid Electric Vehicles (PHEV)	***Gasoline/Diesel Electricity***
Battery Electric Vehicles (BEV)	***Electricity***
Fuel Cell Electric Vehicle (FCEV)	***Hydrogen***

Logit vehicle choice coefficient (β)

Variable	Coefficient
Fuel cost	***-1.066***
Purchase price	***-2.327***
Driving radius	***0.382***
CMDD	***0.517***
PLDD	***0.997***

Vehicle Travel Elasticity Model

$$\textit{Travel distance}_{t} = \text{Initial travel distance}_{t0} \times \text{Factor change to base year}^{\beta LR} \times \text{Travel distance change to base year}^{((\beta LR - \beta SR)/\beta LR)}$$

Factors considered:

- fuel cost
- Income
- vehicle ownership
- efficiency improvement
- urban density

ex. Short run (SR) and long run (LR) elasticity for light vehicle travel

Variable	Short Run	Long Run
Fuel Cost	*-17%*	*-27%*
GDP per Capita	*7%*	*20%*
Vehicles per Capita	*-10%*	*-29%*

Energy demand **= Number of vehicles by technology type x Travel distance x Fuel economy**

Scenario Overview - Transport

- Two scenarios of transport sector: Efficient vehicles and Efficient urban development.
- In the efficient vehicles scenario, the most important factor considered is the fuel efficiency of the fleet. Global Fuel Efficiency Initiative (GFEI) data was used as a reference to make efficiency gains assumptions as follows:

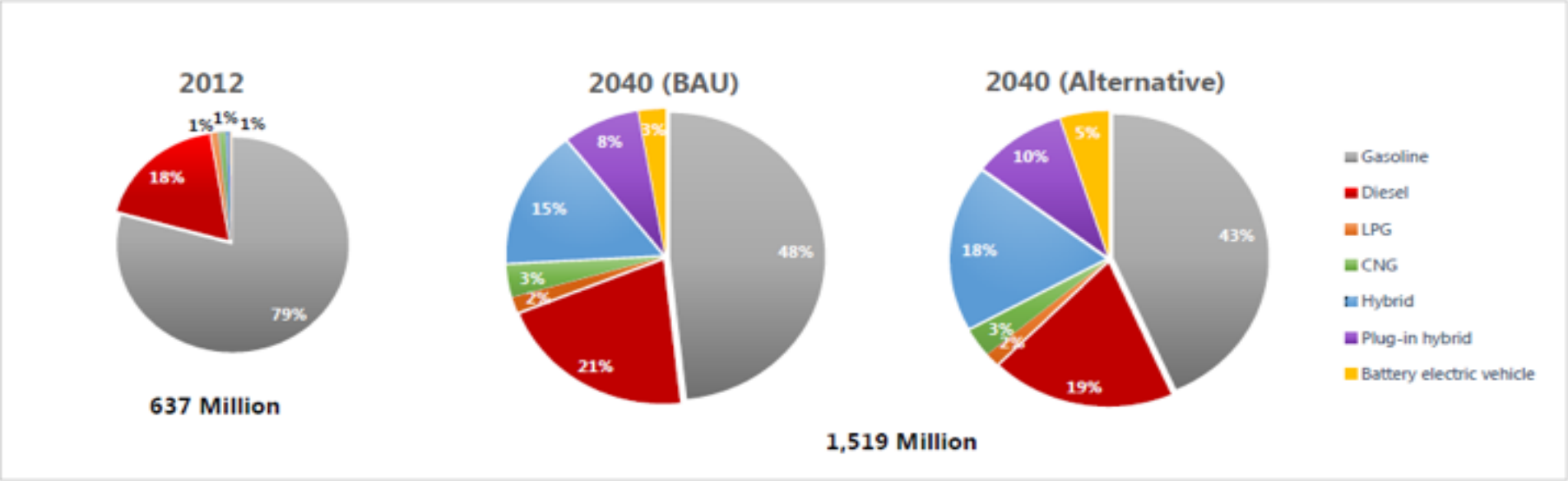
Scenario	Group of economies	Fuel economy improvement (% per	
		2012-2030	2030-2040
BAU	A	1.0%	1.0%
	B	2.0%	1.0%
Alternative	A	2.0%	2.0%
	B	2.7%	2.0%

Group A *is economy where vehicle fuel economy labelling and standard policy has not been currently implemented, which include Brunei Darussalam, Indonesia, Malaysia, Mexico, PNG, Peru, Philippines, Russia, Thailand*

Group B *is economy where vehicle fuel economy labelling and standard policy has been currently implemented, which include Australia, Canada, Chile, China, Hong Kong, Japan, Korea, New Zealand, Singapore, US, Viet Nam, Chinese Taipei*

- New technologies such as electric vehicles also play a role in future energy demand. The model provides estimates of penetration of these technologies and their impact.

Share of Vehicle Technology



(Source: APERC Analysis)

Advanced vehicles also play a role in reducing energy demand in transport, however their adoption remains low

Scenario Overview - Transport

- Efficient urban planning scenario is under development. This scenario will maintain a constant level of urban density, instead of declining at 1.7% per year as the historical world average.