Road Pavements Forum

Energy + *Mobility* and the Economy

SA National Energy Development Institute
Cleaner Mobility
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SANEDI: Cleaner ***Mobility*** Programme

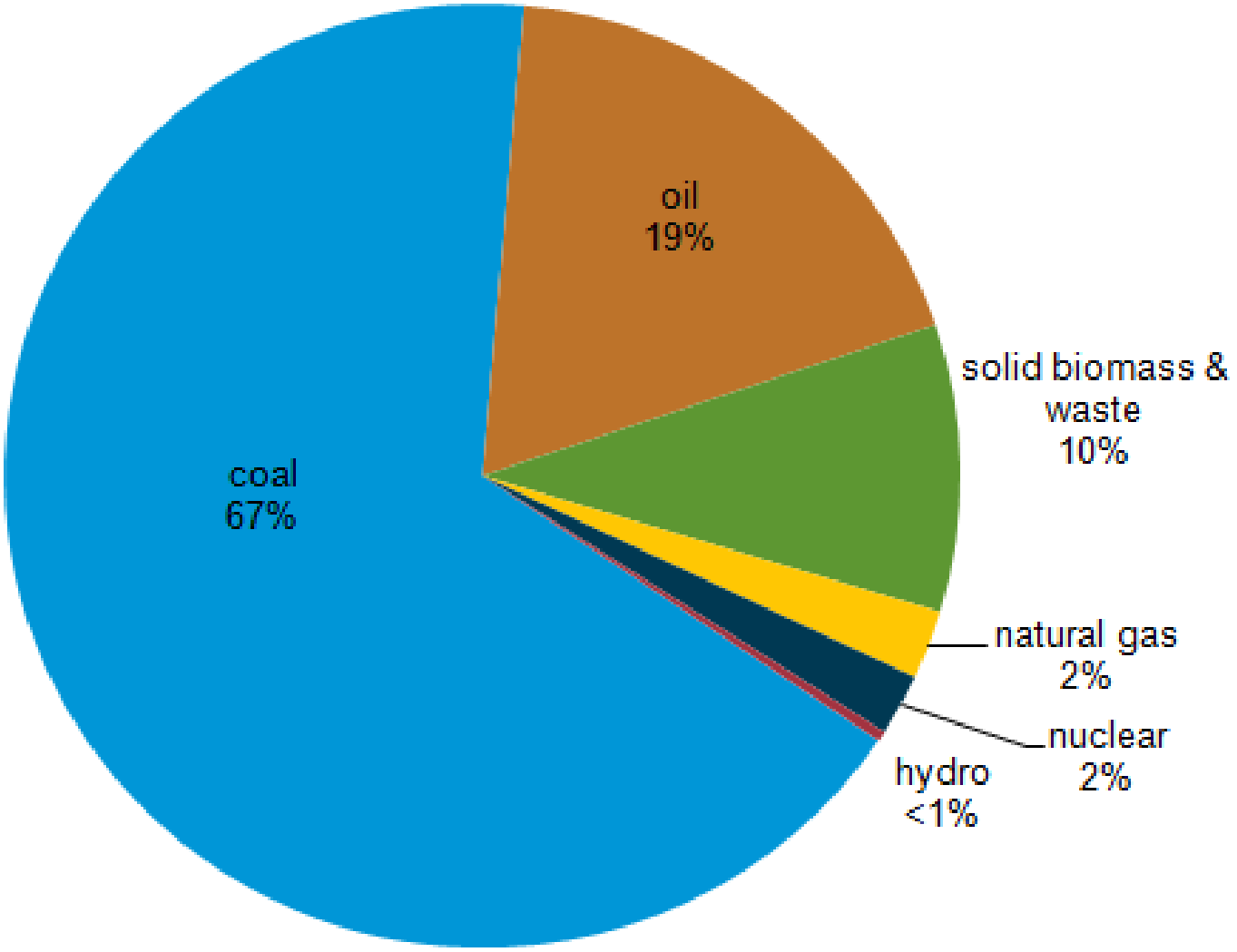
- To find sustainable **energy solutions**
- Considering:
  - the energy used and
  - the technologies applied
- to do work - moving people and freight
- Sustainable means not burning stuff for energy

move away from paying forex for imported energy
reduce energy consumption and emissions like CO_2
develop local energy supply
stimulating local industrial development ➒job creation

We use energy to do work:

- Food - **12** MJ/day (3000 kCal)
- To walk - **0,25** MJ/P.km
- To cycle - **0,11** MJ/P.km or < **0,08**(electric) MJ/P.km
- To drive - **3,2**(petrol) MJ/P.km or **0,6**(electric) MJ/P.km
- To ride - **0,4**(eBus) MJ/P.km **or 0,2**(Train) MJ/P.km

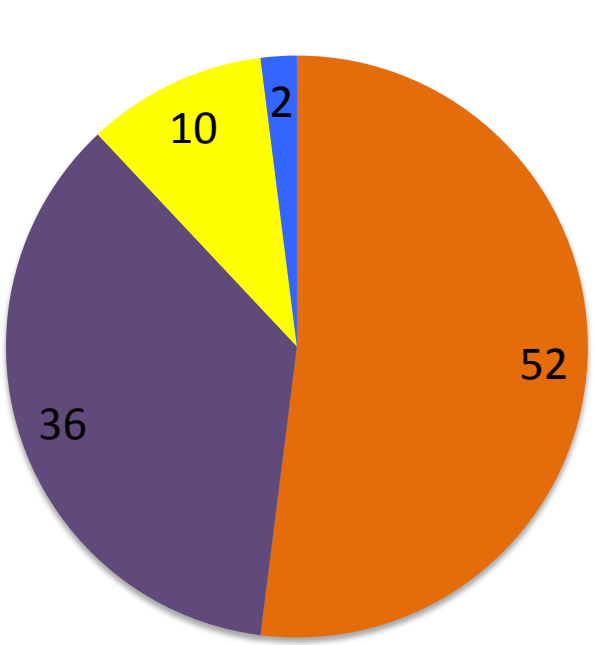
South Africa's Energy Supply



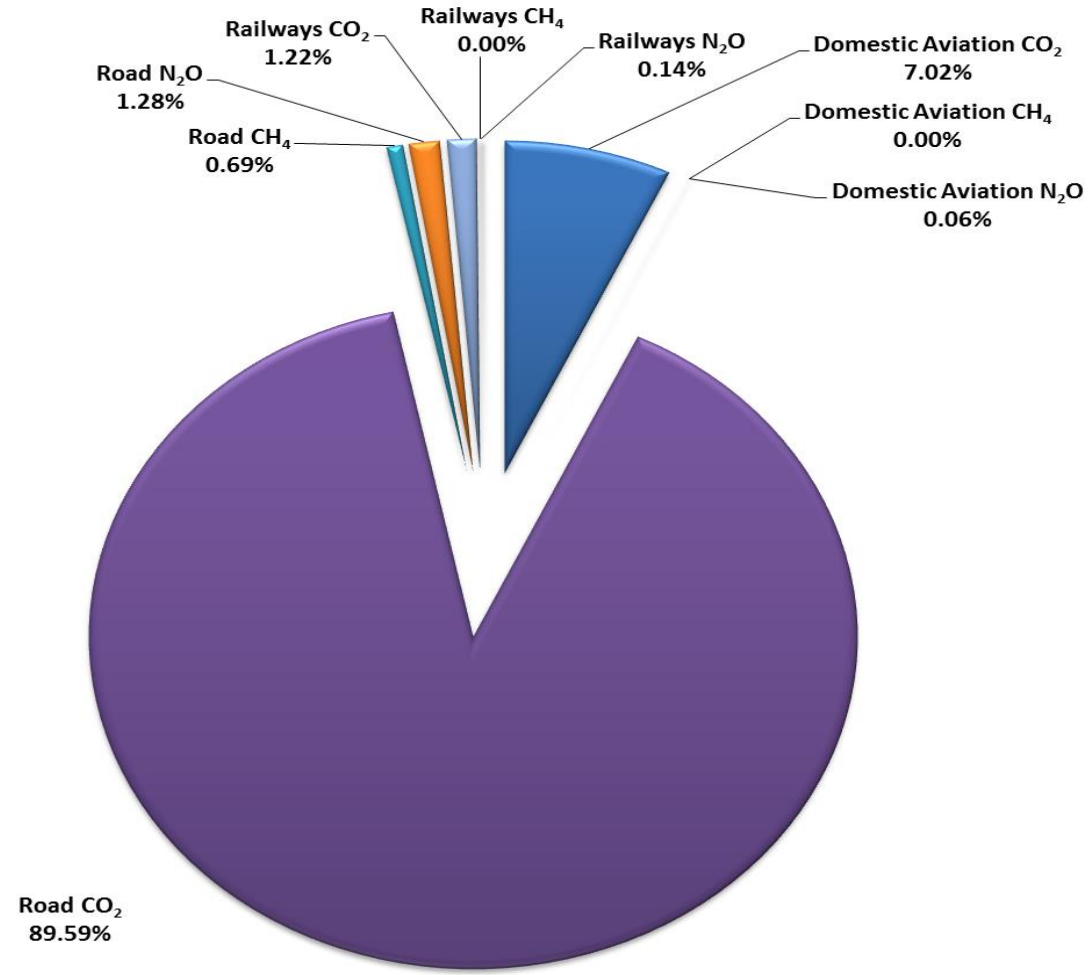
South Africa's Energy Demand (%)

Economic Sector	2010	2050
Industry	***37***	***34***
Mining	***8***	***4***
Agriculture	***3***	***3***
Commerce	***7***	***7***
Residential	***11***	***8***
Transport	***34***	***44***

Transport energy use & impact

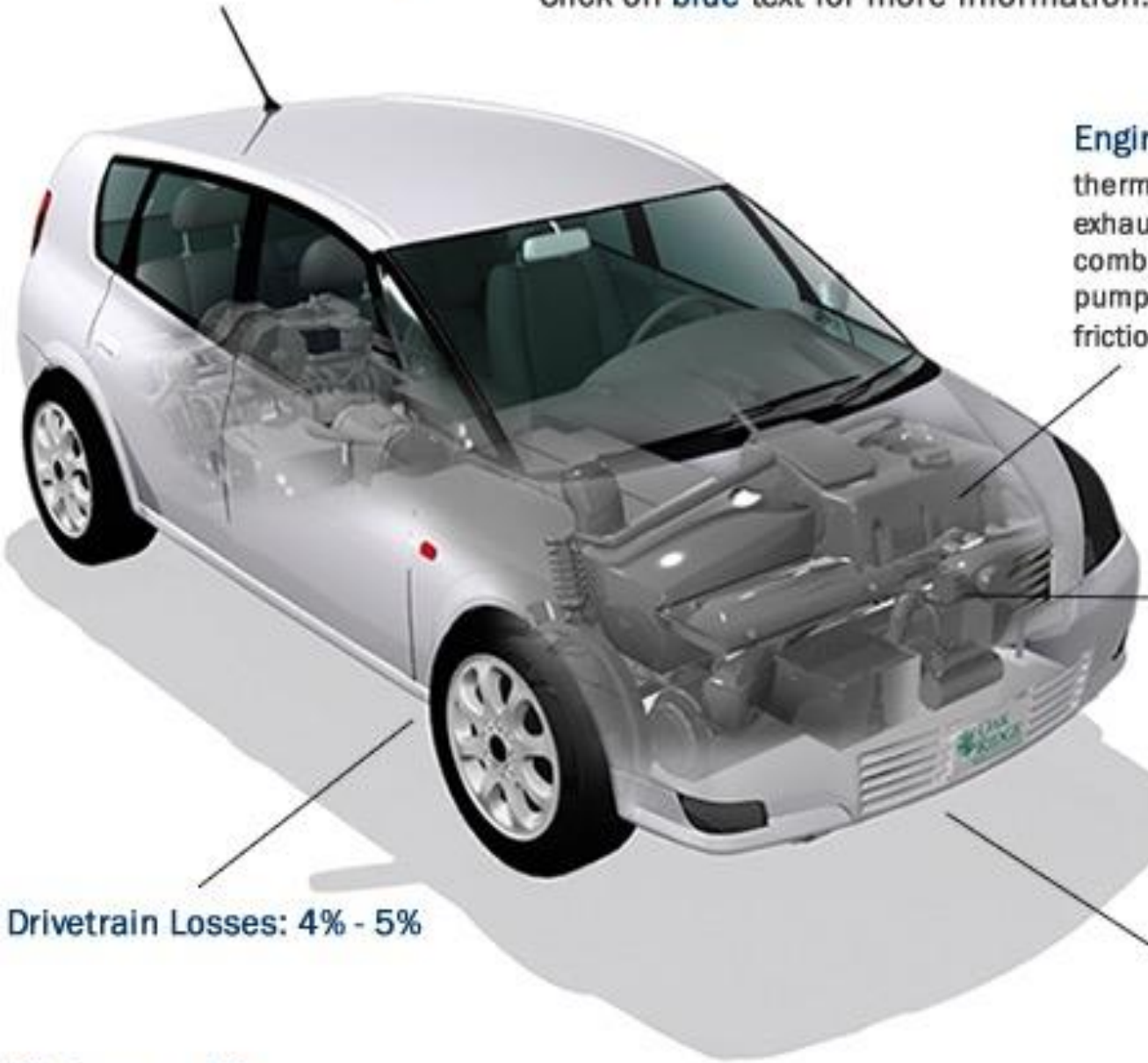


- Petrol
- Diesel
- Jet Fuel
- Electricity



Energy Requirements for City (Stop and Go) Driving

Click on blue text for more information.



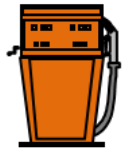
Engine Losses: 74% - 75%
thermal, such as radiator, exhaust heat, etc. (63% - 64%)
combustion (3%)
pumping (5%)
friction (3%)

Parasitic Losses: 6% - 7%
(e.g., water pump, alternator, etc.)

Drivetrain Losses: 4% - 5%

Power to Wheels: 14% - 16%
Dissipated as
wind resistance: (4%)
rolling resistance (4% - 5%)
braking (6% - 7%)

Idle Losses: 6%
In this figure, they are accounted for as part of the engine and parasitic losses.

Oil Well	Refinery	Distribution	Petrol Car	(W→W)η
				15%
96%	90%	97%	18%	

Coal Mine	Synfuel Plant	Distribution	Petrol Car	
				7%
97%	40%	97%	18%	

Coal Mine	Power Station	Distribution	Electric Car	
				24%
97%	35%	95%	75%	

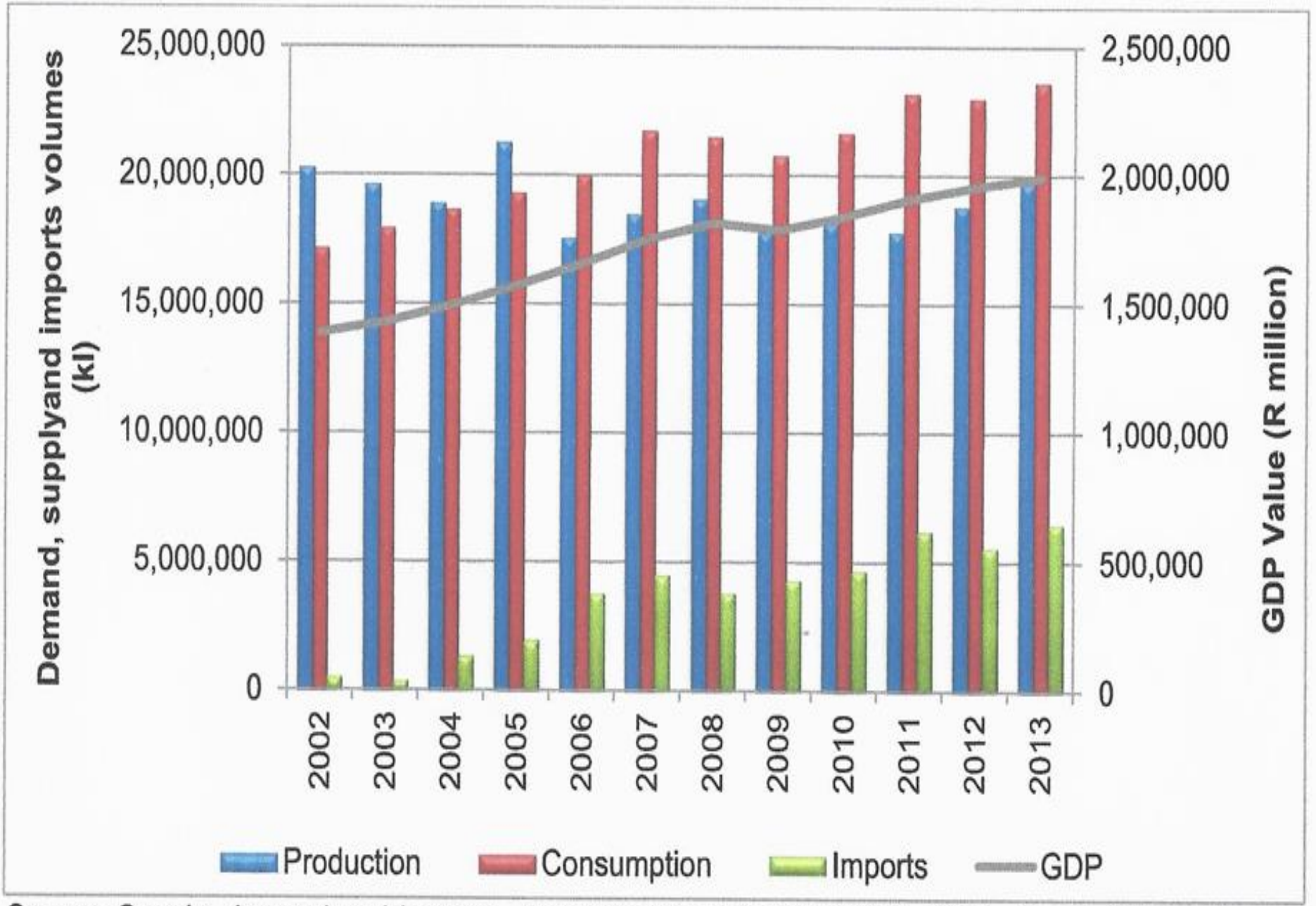
Solar Farm	Distribution	Electric Car	
 			71%
	95%	75%	

Road: Modes & energy performance

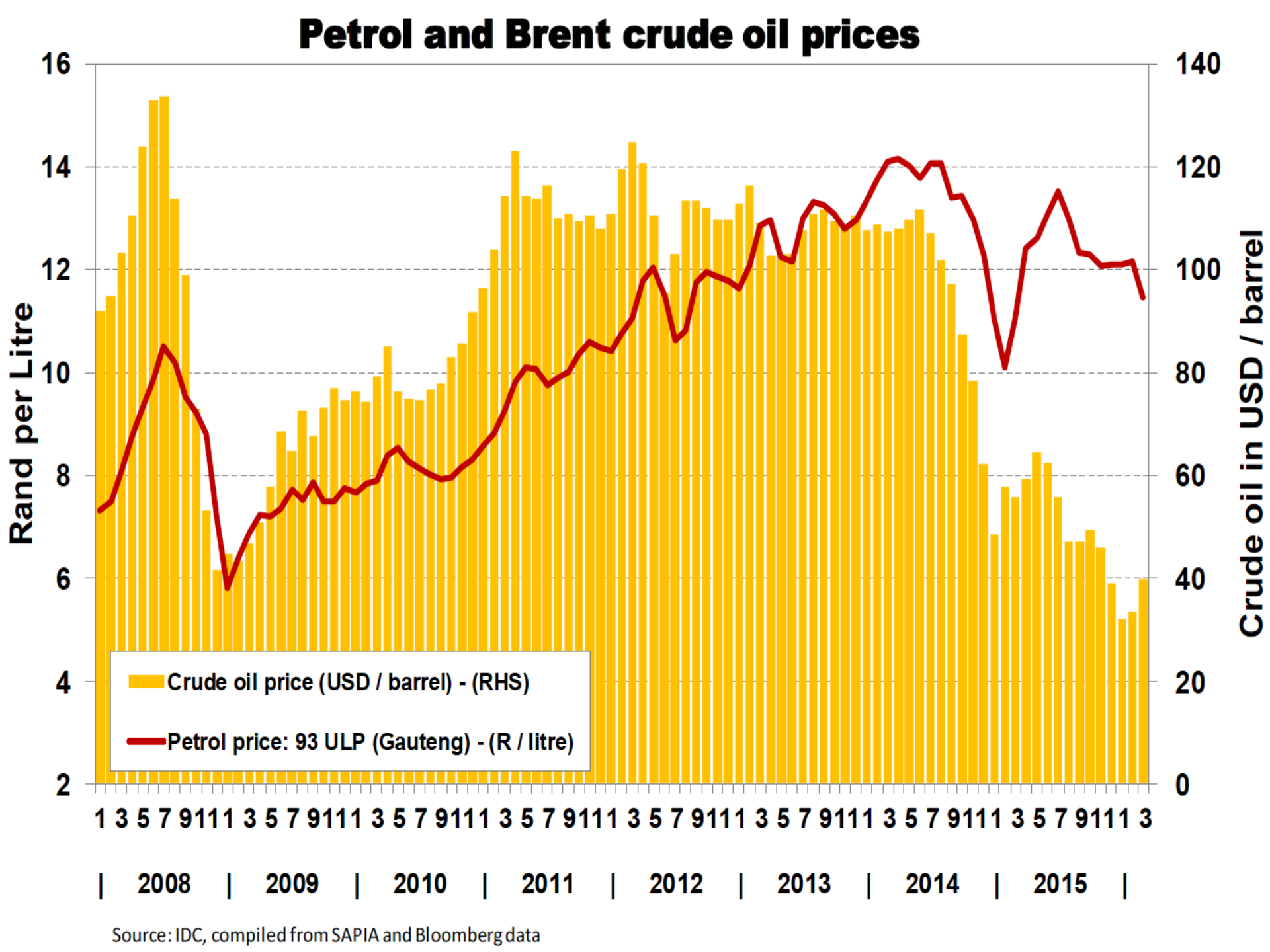
Mode	Energy	Number	%	Load Capacity	Unit /100km	MJ/P.km MJ/T.km	gCO_2/P.km gCO_2/T.km
Car	Petrol	4'455'038	57%	1.4	9.0	2.19	153.77
	Diesel	184'407	2%	1.4	7.0	1.90	119.60
SUV	Petrol	442'621	6%	1.4	14.0	3.40	239.20
	Diesel	279'222	4%	1.4	11.0	2.99	187.94
LCV	Petrol	1'103'608	14%	0.5	13.0	8.84	621.92
	Diesel	700'265	9%	0.5	10.0	7.60	478.40
MCV	Petrol	5'991	0.1%	2.5	33.0	4.49	315.74
	Diesel	131'425	2%	2.5	25.7	3.90	245.58
HCV	Diesel	198'134	3%	15	38.0	0.96	60.60
MBTaxi	Petrol	260'577	3%	14	15.0	0.36	25.63
	Diesel	13'976	0.2%	14	11.7	0.32	19.93
Bus	Diesel	30'033	0.4%	25	33.0	0.50	31.57

Road: Modes & Energy Impacts

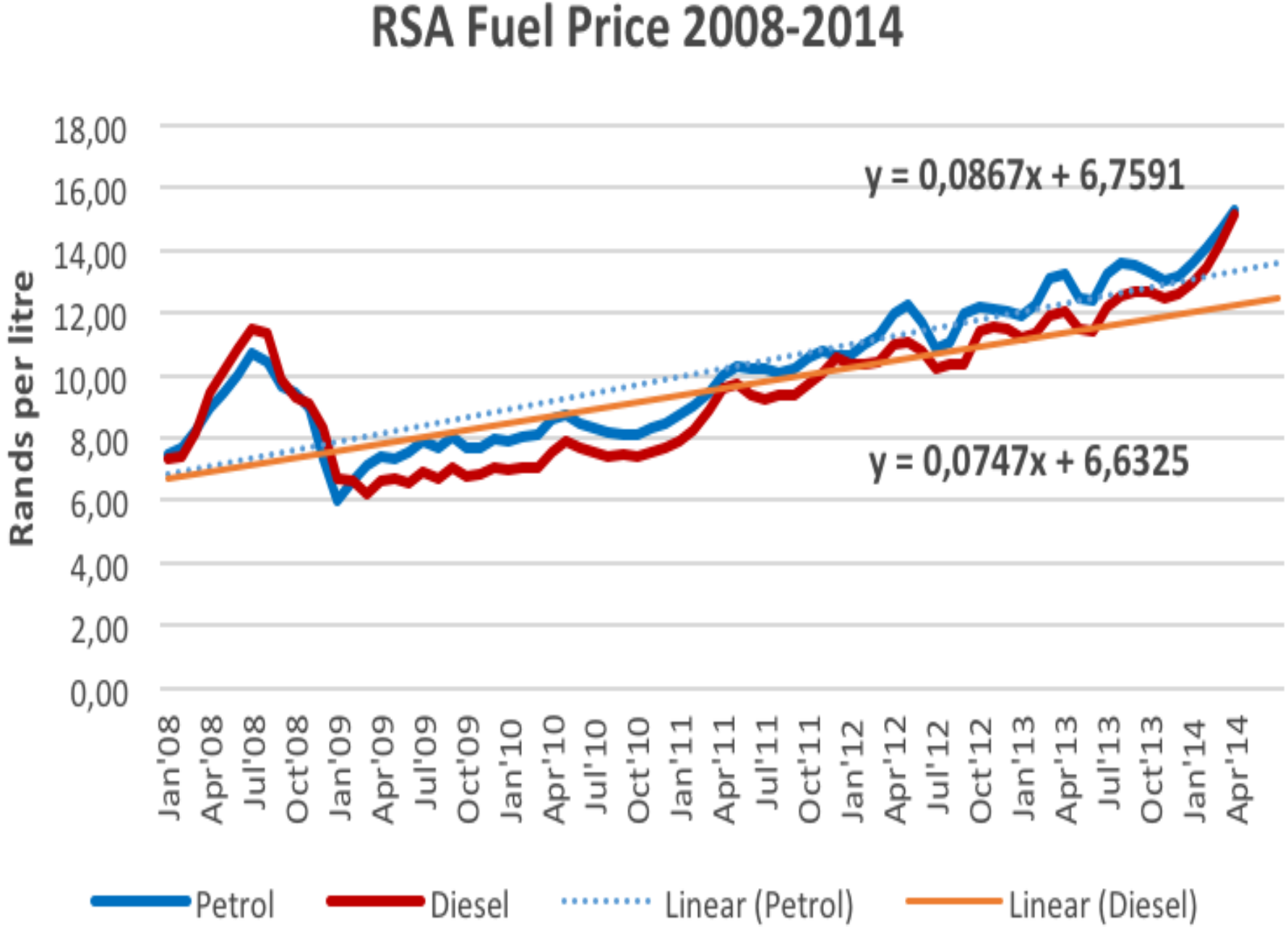
Mode	Energy	Number	%	Vkm/ year	MP.km MT.km	Mlitre	GJ	% GJ	MTon CO_2
Car	Petrol	4'455'038	57%	24'000	149'689	9'623	327	35%	23.02
	Diesel	184'407	2%	24'000	6'196	310	12	1%	0.74
SUV	Petrol	442'621	6%	24'000	14'872	1'487	51	5%	3.56
	Diesel	279'222	4%	24'000	9'382	737	28	3%	1.76
LCV	Petrol	1'103'608	14%	25'000	13'795	3'587	122	13%	8.58
	Diesel	700'265	9%	25'000	8'753	1'751	67	7%	4.19
MCV	Petrol	5'991	0.1%	45'000	674	89	3	0.3%	0.21
	Diesel	131'425	2%	25'000	8'214	843	32	3%	2.02
HCV	Diesel	198'134	3%	70'500	209'527	5'308	202	22%	12.70
MBTaxi	Petrol	260'577	3%	50'000	182'404	1'954	66	7%	4.67
	Diesel	13'976	0.2%	50'000	9'783	82	3	0.3%	0.20
Bus	Diesel	30'033	0.4%	40'000	30'033	396	15	2%	0.95



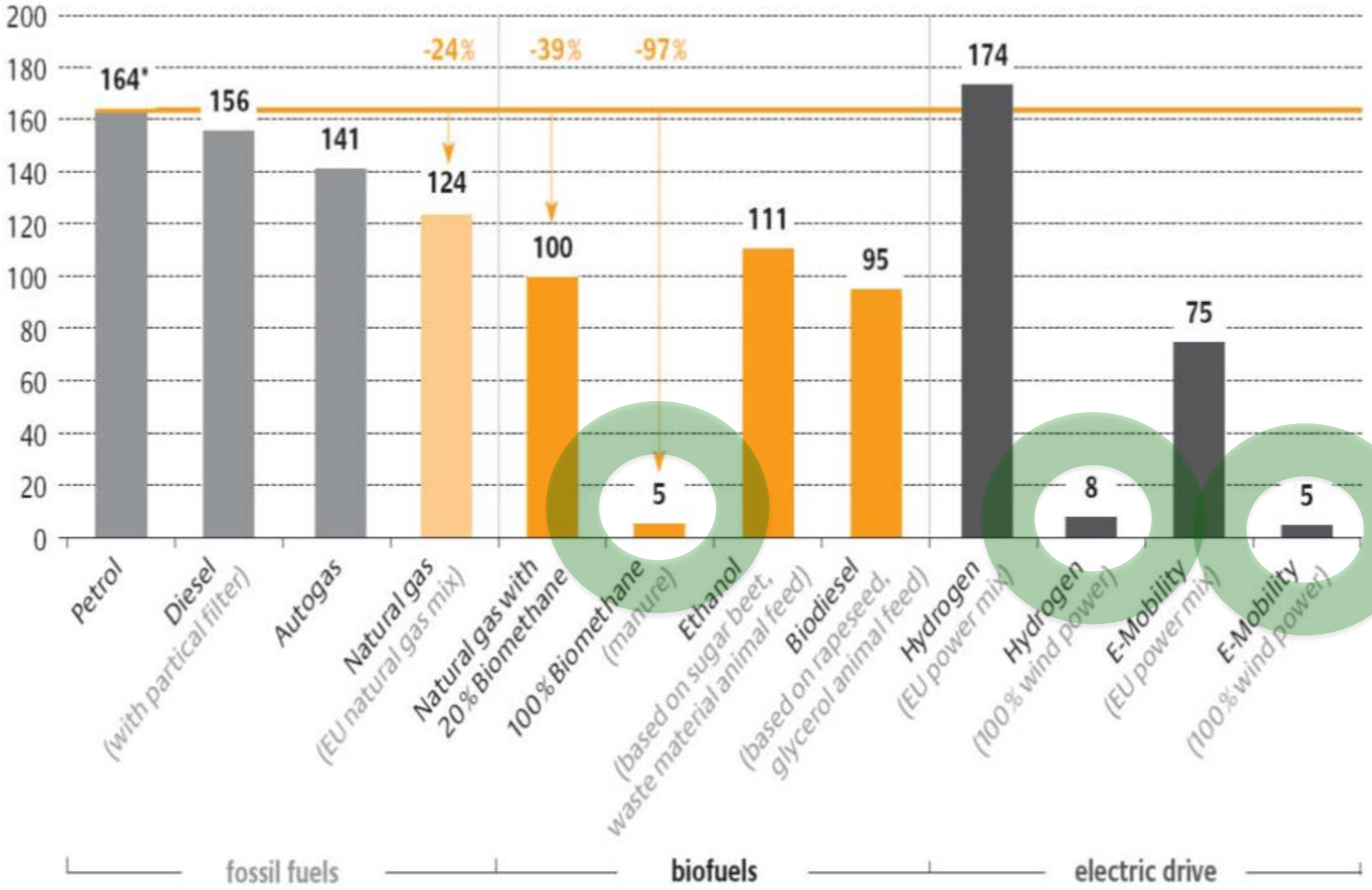
Source: Supply, demand and imports - Department of Energy (DOE), GDP - South African Reserve Bank (SARB)



Source: IDC, compiled from SAPIA and Bloomberg data


RSA Fuel Price 2008-2014
Rands per litre
18,00
16,00
14,00
12,00
10,00
8,00
6,00
4,00
2,00
0,00
y = 0,0867x + 6,7591
y = 0,0747x + 6,6325
Jan'08
Apr'08
Jul'08
Oct'08
Jan'09
Apr'09
Jul'09
Oct'09
Jan'10
Apr'10
Jul'10
Oct'10
Jan'11
Apr'11
Jul'11
Oct'11
Jan'12
Apr'12
Jul'12
Oct'12
Jan'13
Apr'13
Jul'13
Oct'13
Jan'14
Apr'14
Petrol
Diesel
Linear (Petrol)
Linear (Diesel)

Well to Wheel GHG emissions in $gCO_{2eq.}/km$



* reference vehicle: gasoline engine (induction enginge), consumption 7 l per 100 km

How much energy/hectare/year?

Photosynthesis: 2% of 20'000GJ/ha and cultivation period ➔ 400GJ/ha/yr

Processing: 50-135GJ BioFuels/ha/yr (BioEtOH, BioDiesel, BTL)

Distribution & Combustion: 35% (Fuel to Wheel)

18-47GJ/ha/year

Solar beats Biomass 40-100 times!

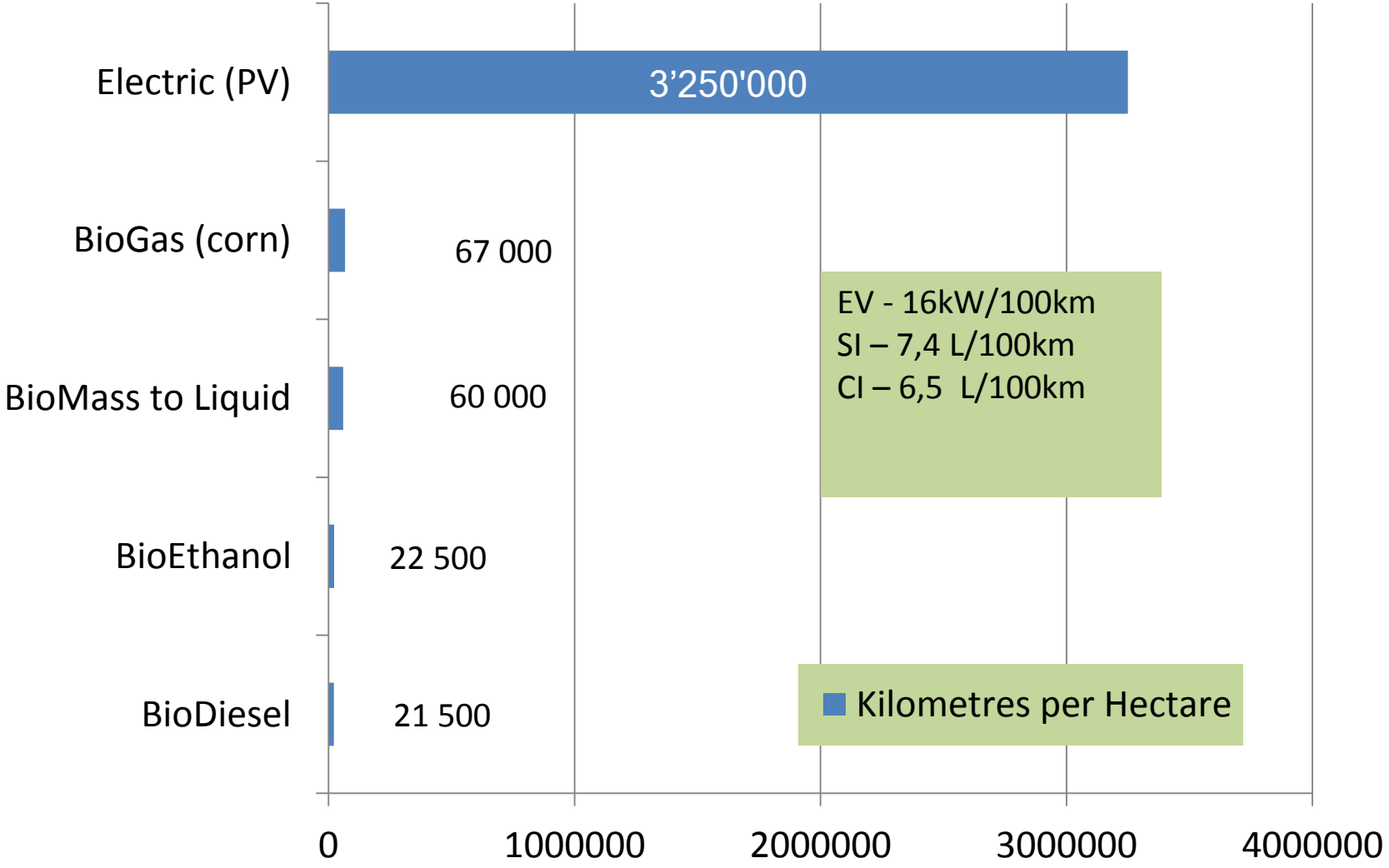
PV Cell to grid: 10% efficient ➔ 3'600GJ/ha/yr

Inverter {dc ➔ ac} 90% efficient 3'050GJ available for car battery

From battery to wheel: 60% efficient

1'800GJ/ha/year

How many km per hectare?



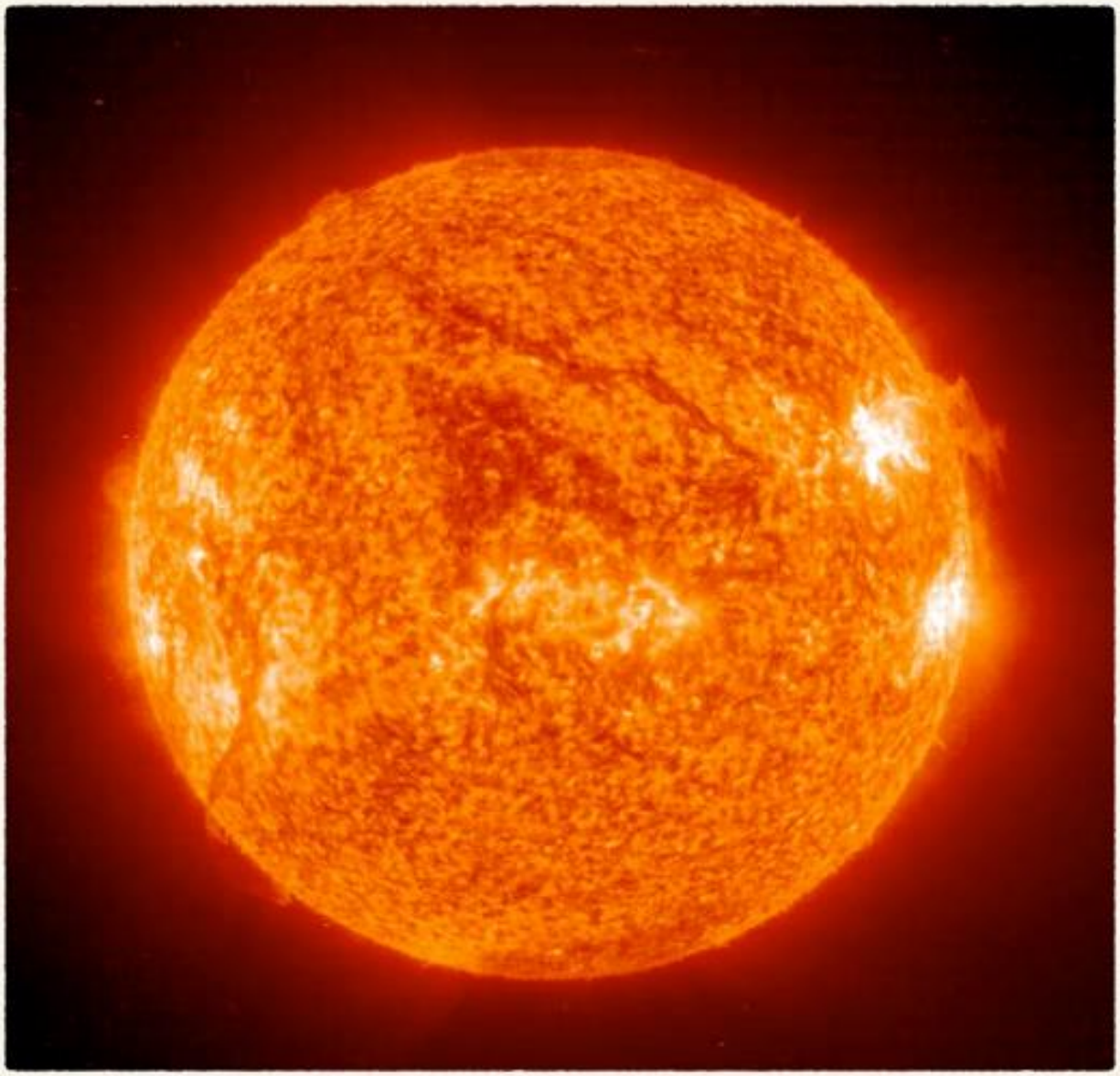
Driving on Sunshine!

Solar powered electric bus

- Adelaide Australia – “Tindo” after the Aboriginal word for "sun”
- World's first 100% solar-recharged electric transit bus
- Seats 27
- 35kW electric motor
- 262kWh ZEBRA sodium nickel chloride batteries

11,480kg vehicle, top speed of 75km/hour and an estimated operating range between fast charges is 200km

Where do find energy?



Solar

Wind

Biomass

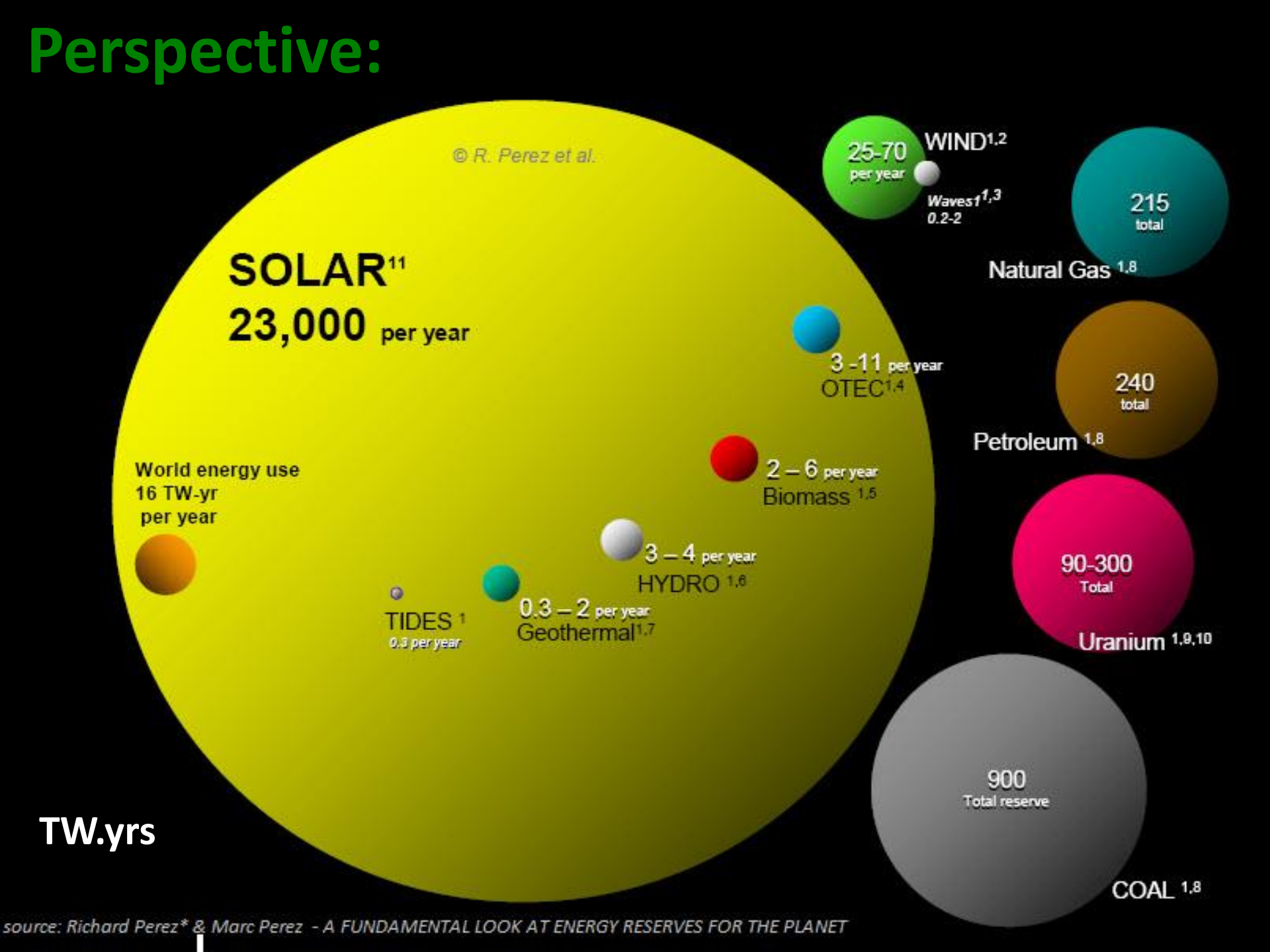
Tides

Gas

Oil

Coal

Perspective:



source: Richard Perez* & Marc Perez - A FUNDAMENTAL LOOK AT ENERGY RESERVES FOR THE PLANET

Petroleum Scenario

- 7 million petrol vehicles in SA
- On average travelling 20’000km/yr
- Using 10litres of petrol per 100km
- That is in total 14billion liters of petrol
- SA imports
  - 138million barrels of oil
  - 840million liters of petrol

Petroleum Impact

- **476PJ** of energy
- Public pays R196billion
  - Fuel cost = R82Bn
  - Margins & Costs = R39Bn
  - Levies = R73Bn
- Forex R109billion

Cost, Energy and Carbon

For 100km:	Petrol Car	Electric Car	
		Normal	Off-peak & Small Car
Price/Unit	R 13,33	R 1,33	R1,00
Units	9 litres	20 kWh	5 kWh
Energy	306 MJ	72 MJ	18 MJ
Cost	R 120,00	R 26,60	R7,00
CO_2	38kg	20kg	5kg

Eskom Electricity Scenario

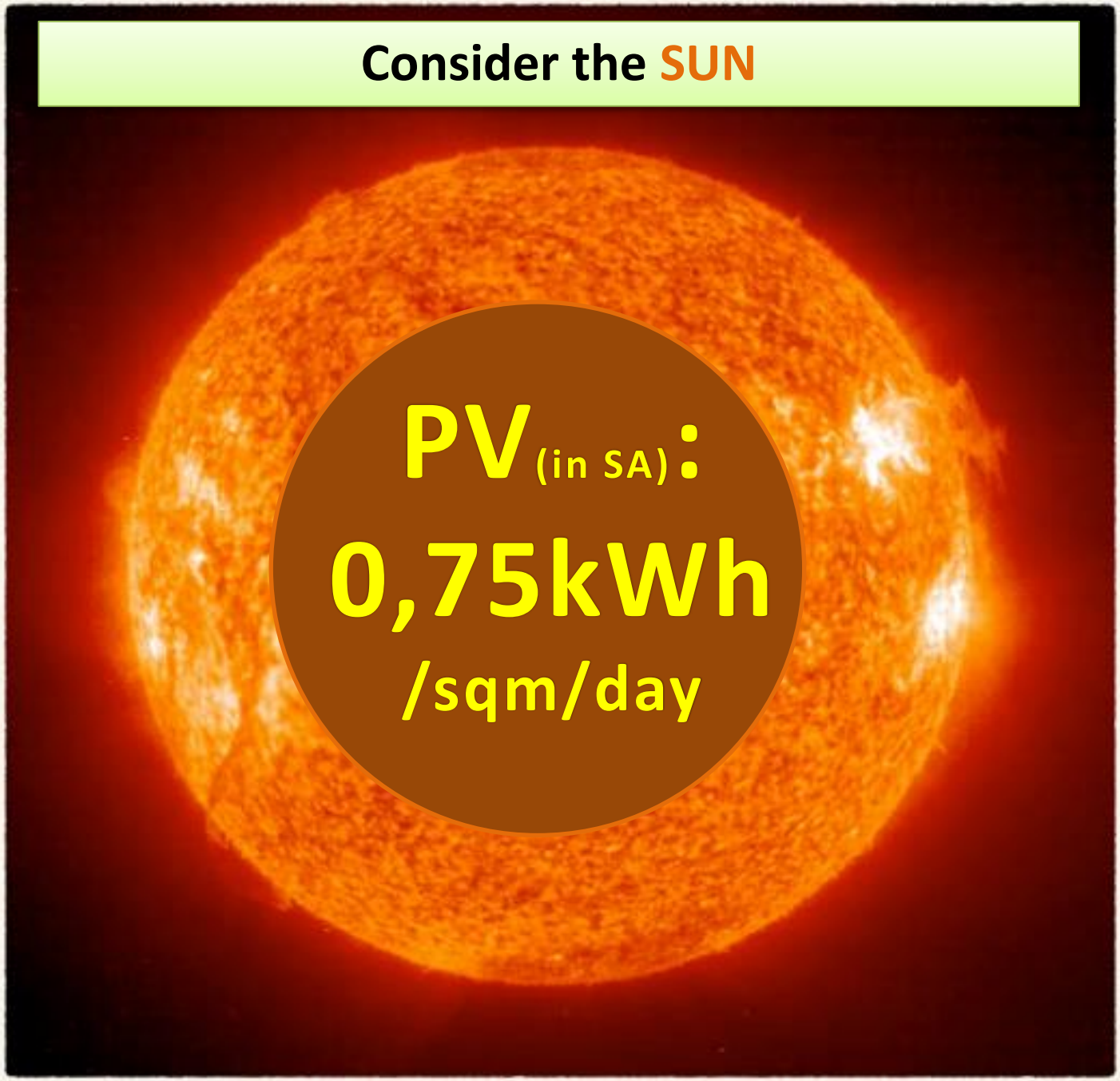
- **7 million electric vehicles** in SA
- On average travelling 20’000km/yr
- Using **20kWh of electricity** per 100km
- That is in total **28TWh electricity**
- Local energy sources

(231TWh is current declining consumption)

Eskom Electricity Impact

- **101PJ** of energy
  - (4 times less or -400%)
- Public pays **R42billion**
- Emissions at source
- No Forex
- Utilise surplus electricity
- Support the grid

Consider the SUN



How far can I go on only one square meter solar PV energy?

Consider the SUN

eBike @35 P.km

eScooter @23 P.km

Train @13 P.km

3 Wheeler @13 P.km

Bus @7 P.km

4 Wheeler @ 8 P.km

Nissan Leaf @4 P.km

How far can I go on only one square meter solar PV energy?

Energy from the SUN

- Average = 80km per day
- Small electric commuter:

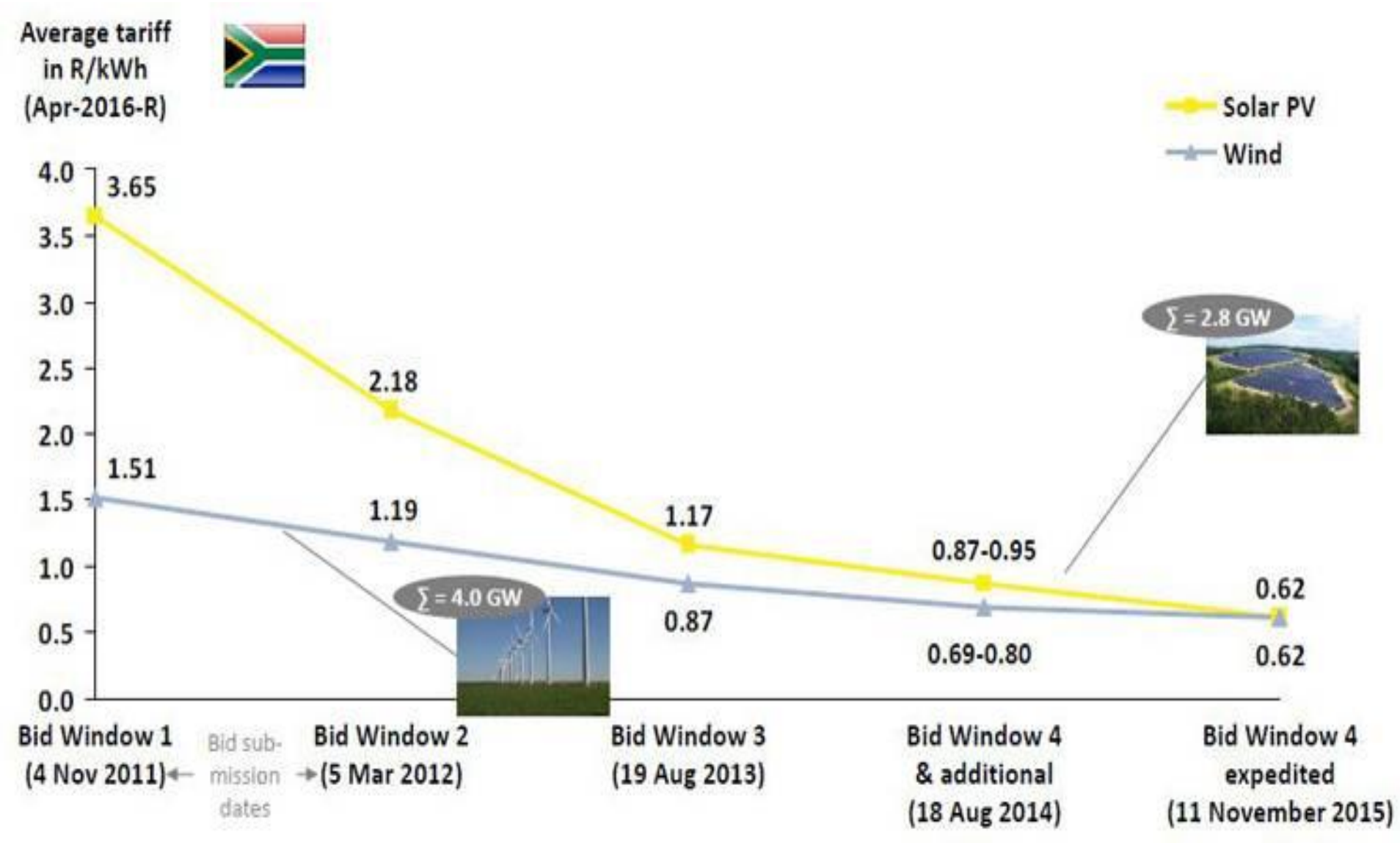
  5kWh/100km = 4kWh/day
- PV electrical energy
  - 5kWh per day
  - 1kW array = 5 x 200W panels
  - $10m^2$
- PV cells cost – R50’000,

  once-off, for 25 years
- PV life = 500’000km
- **10c/km (no increase!)**

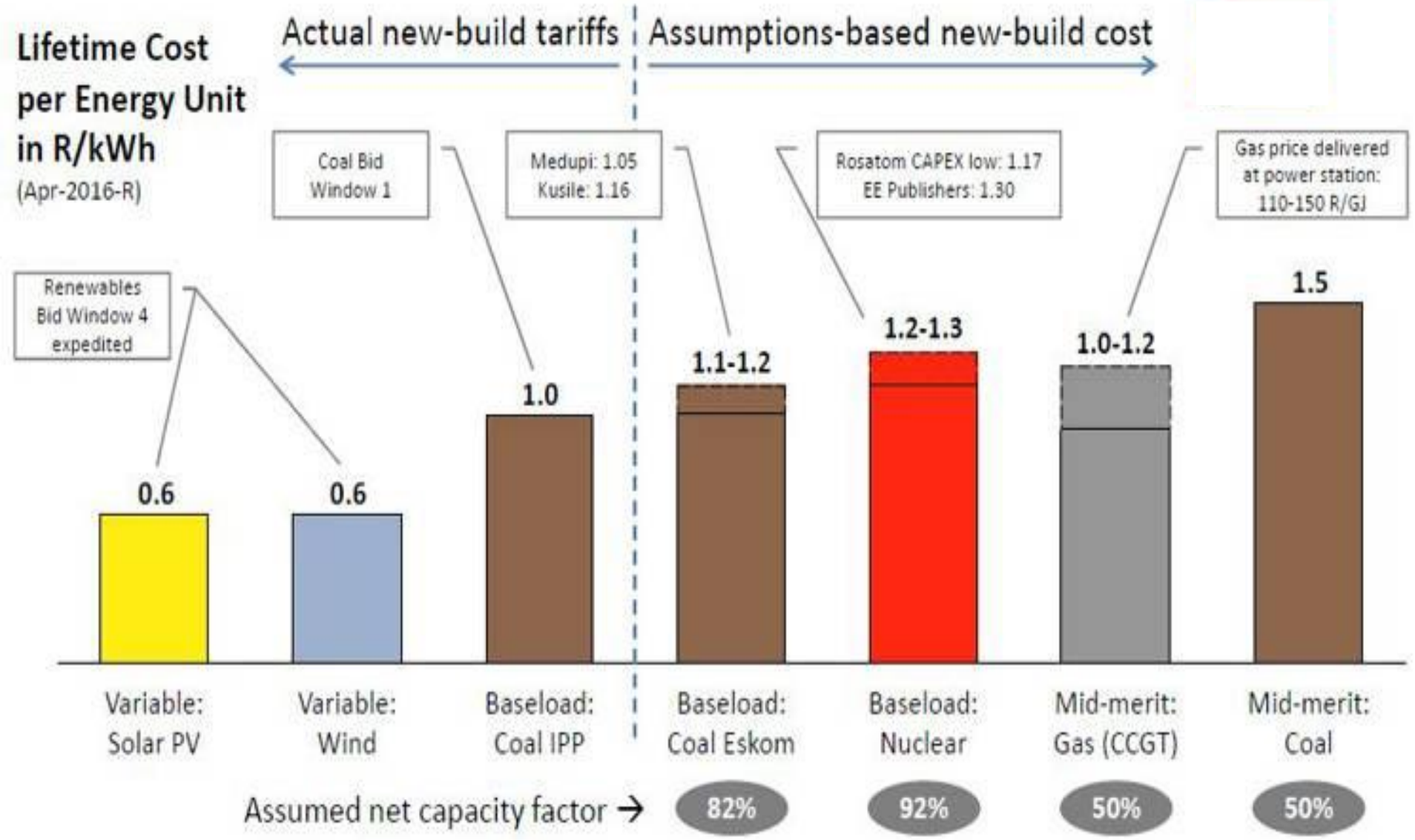

acciona

Powered by PV

Bid prices for Renewables in SA



Comparison of Electricity Prices



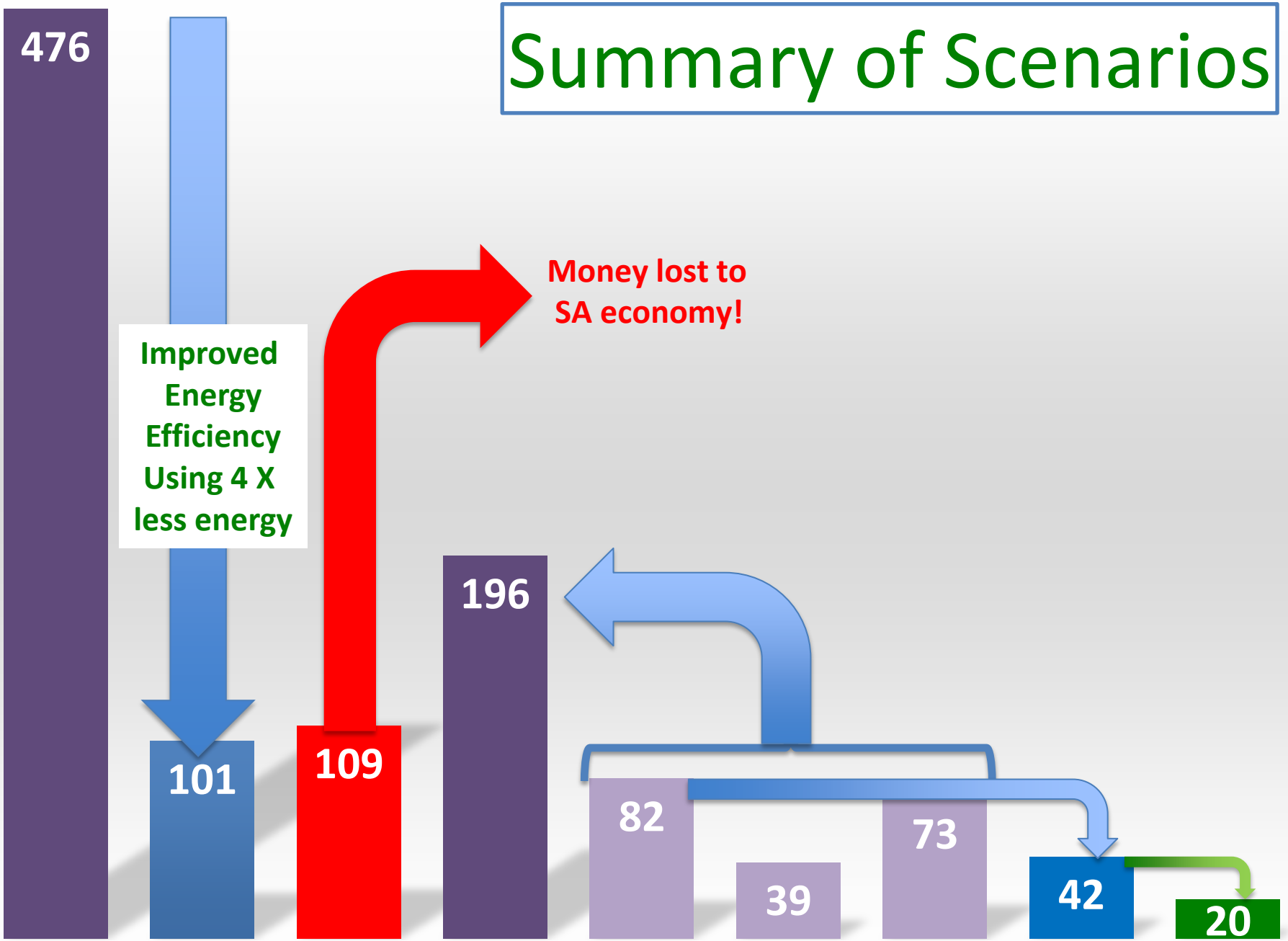
Renewables Scenario

- **7 million electric vehicles** in SA
- On average travelling 20’000km/yr
- Using **20kWh of electricity** per 100km
- That is in total **28TWh solar electricity**
- Sustainable energy from the **sun**

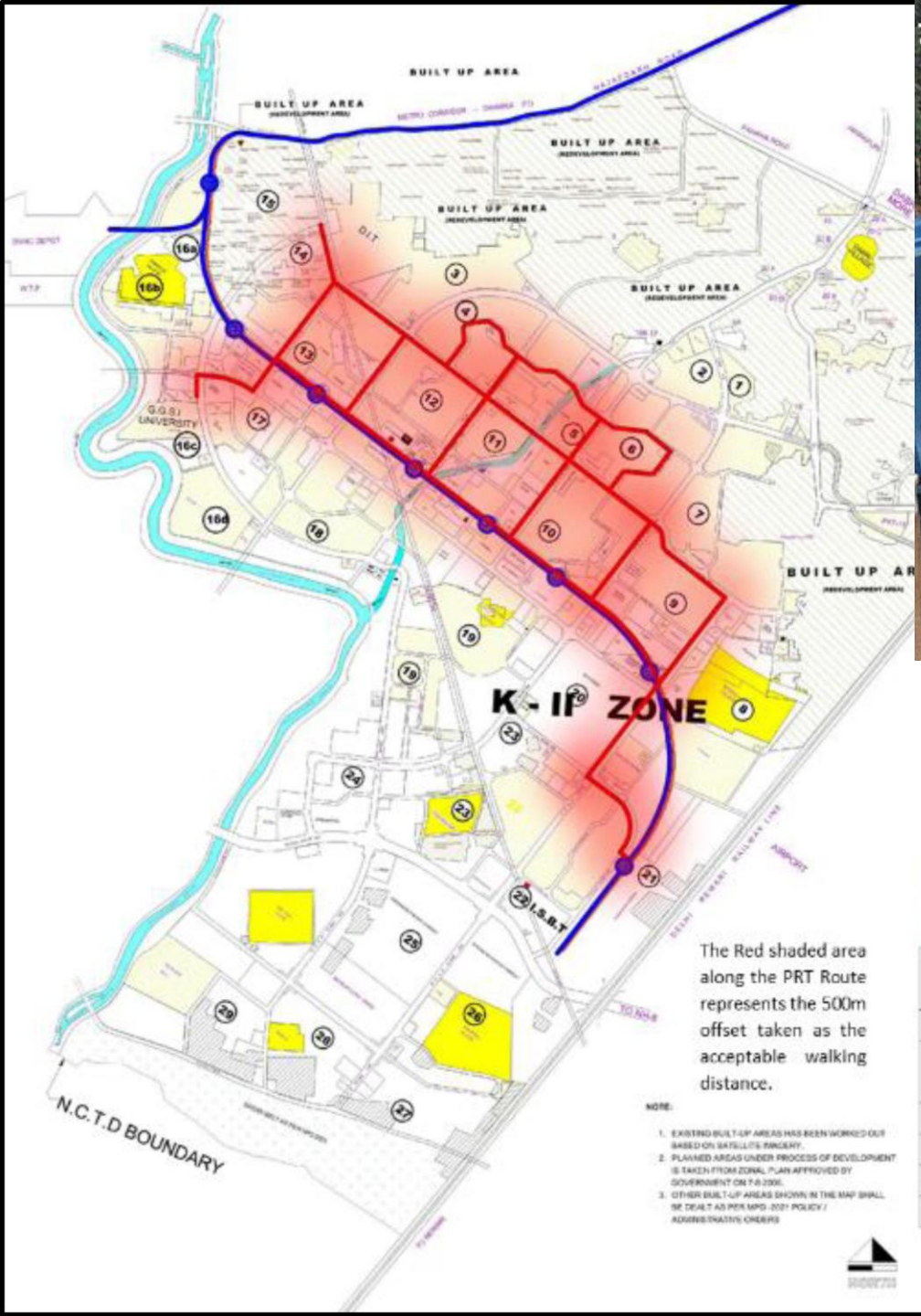
Renewables Impact

- **101PJ** of energy
  - (4 times less or -400%)
- Public pays **R20billion**
  - Fuel cost = **R20Bn (R40Bn with storage)**
- No Forex
- No emissions
- Sustainable!

Summary of Scenarios

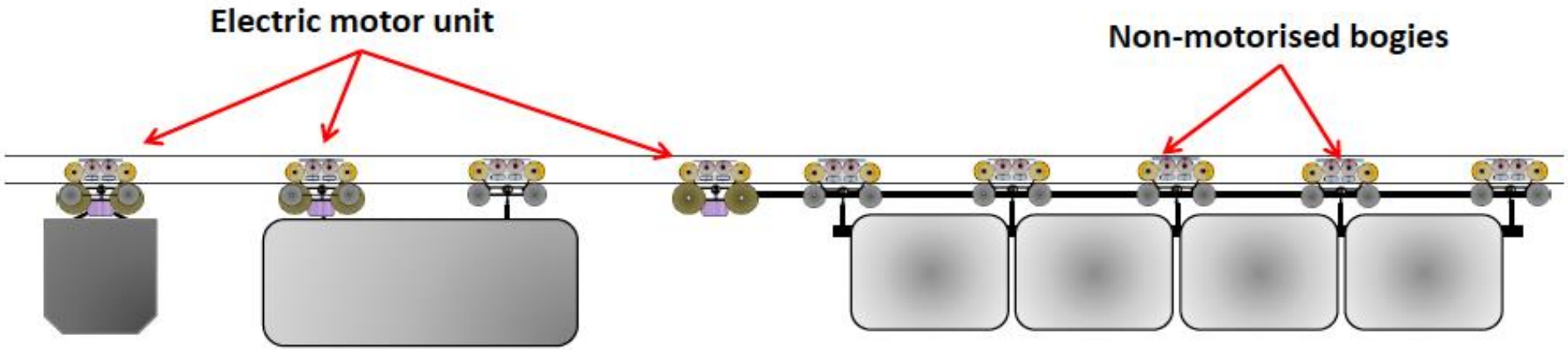


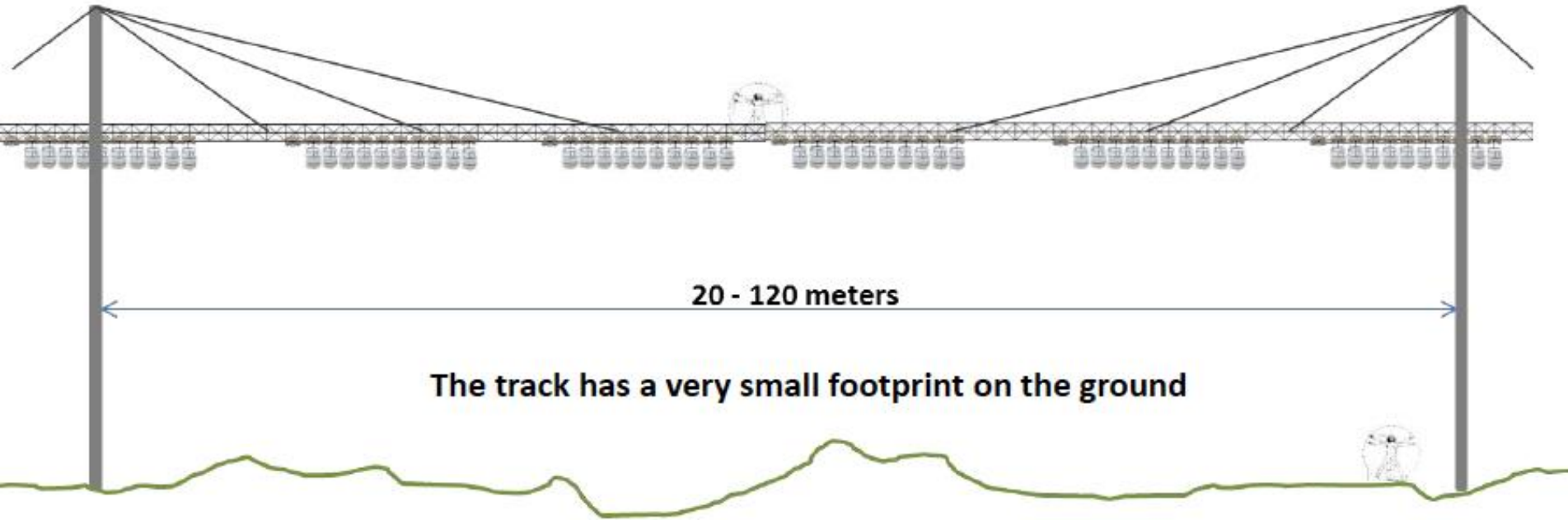

Russell Brands
ALDO
LONDON TRANSPORT
ROUTEMASTER
ROUTEMASTER
Merry Christmas
from
MRS
JOY UP


BUILT UP AREA
BUILT UP AREA
BUILT UP AREA
BUILT UP AREA
BUILT UP AREA
K - II ZONE
G.G.S.I UNIVERSITY
I.S.B.T
N.C.T.D BOUNDARY
The Red shaded area along the PRT Route represents the 500m offset taken as the acceptable walking distance.
Metro Stations
Metro Route
PRT Route
LEGEND
PLANNED DEVELOPMENT
BUILT-UP RESIDENTIAL (VILLAGES)
BUILT UP AREA
OTHER BUILT-UP AREA
PLANNED AREA
METRO ROUTE & STATION
GREEN BELT AS PER MPD 2021


Three PRT 2000 Vehicles on Raytheon Test Track, August, 1998
Source: Raytheon Company

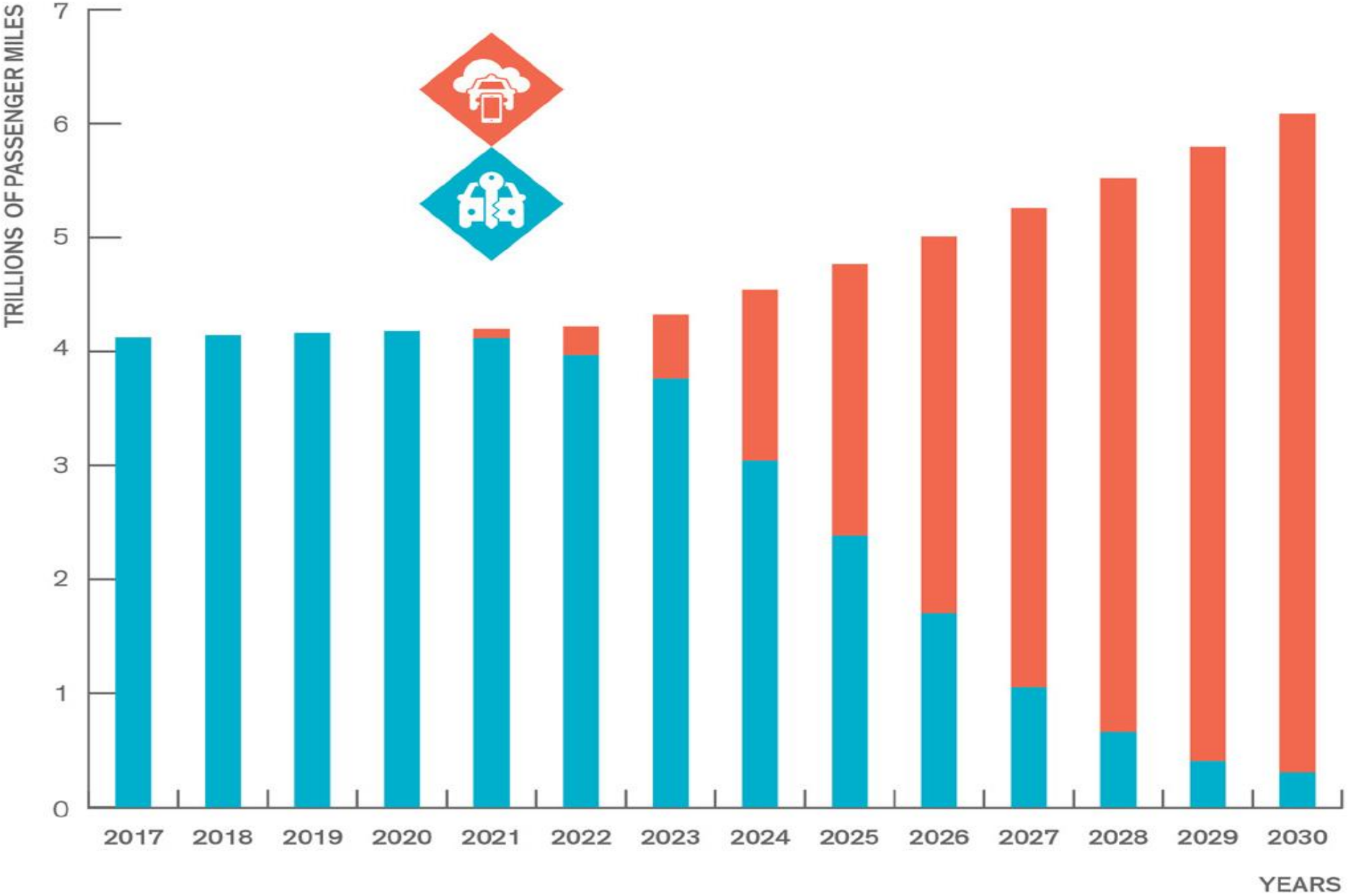
Do not compete – find right of way



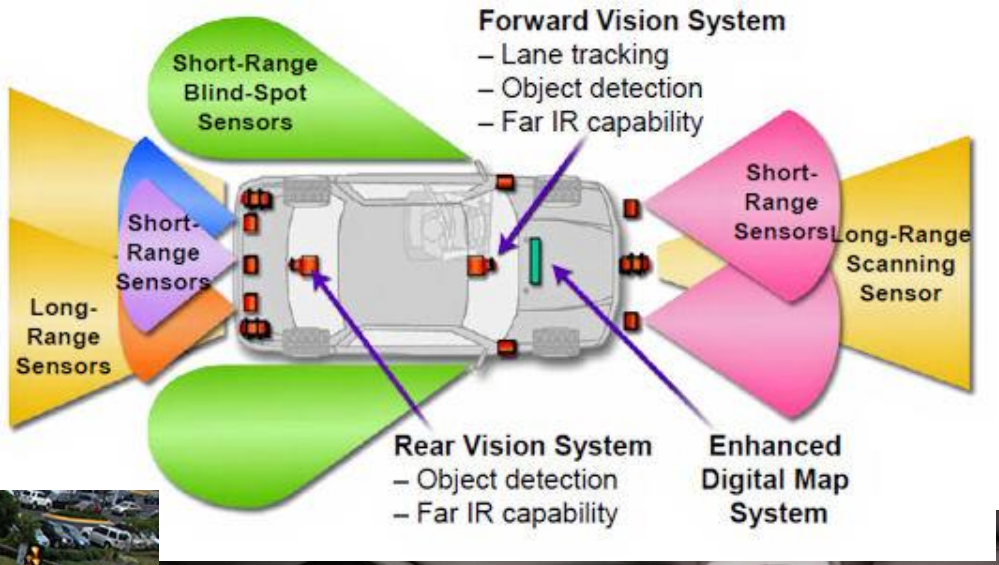


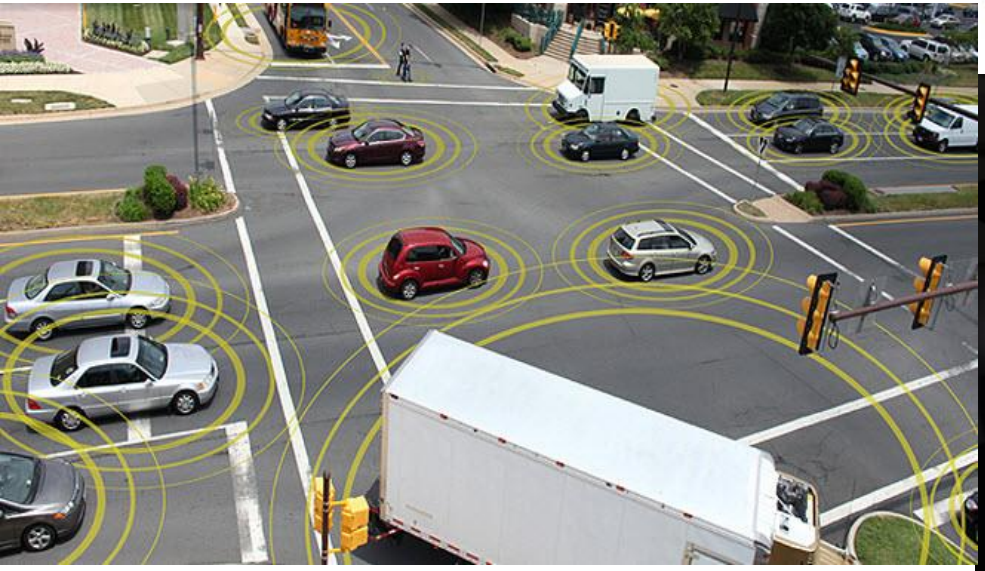
Overhead Personal Rapid Transit

» Speed of TaaS adoption



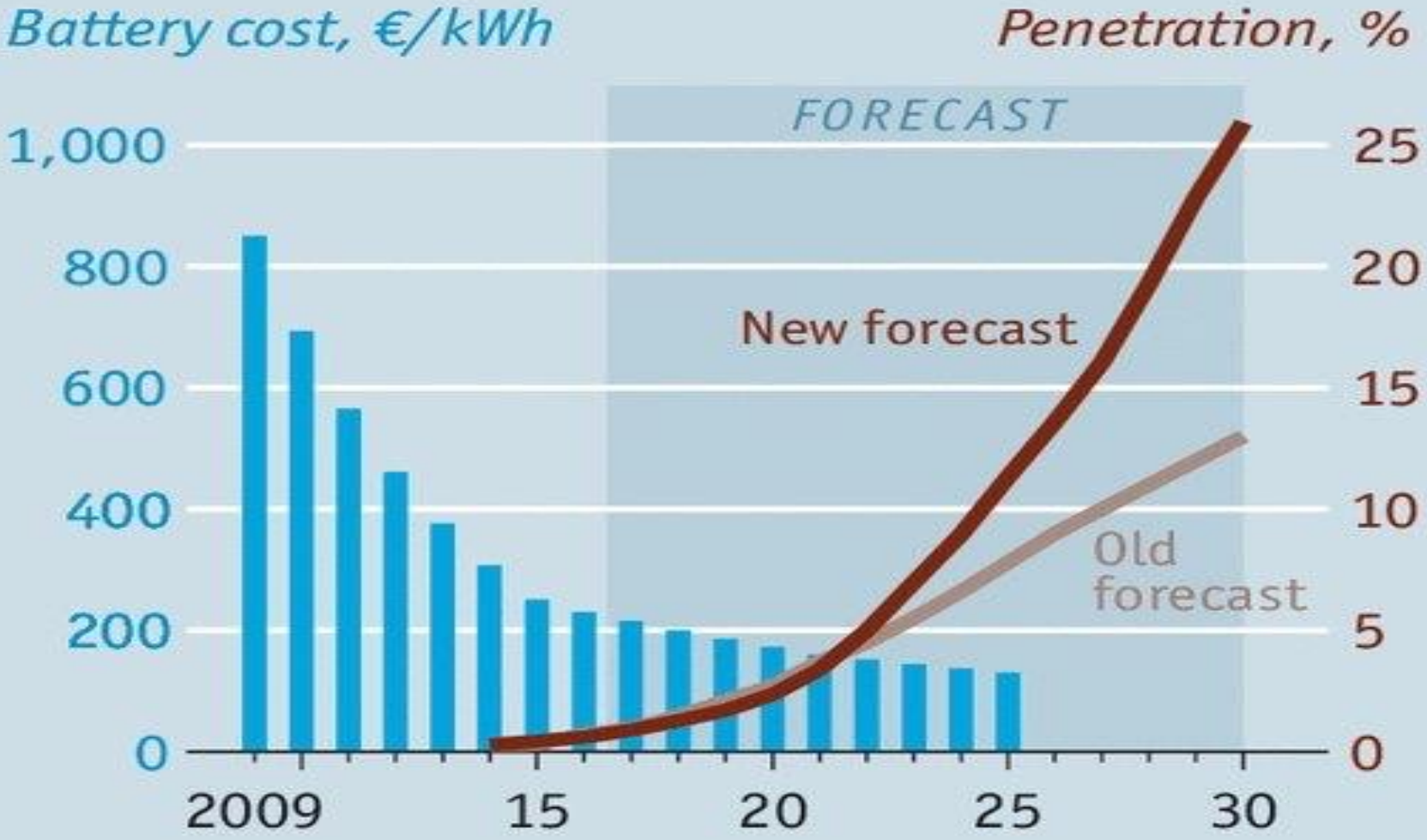
Autonomous cars





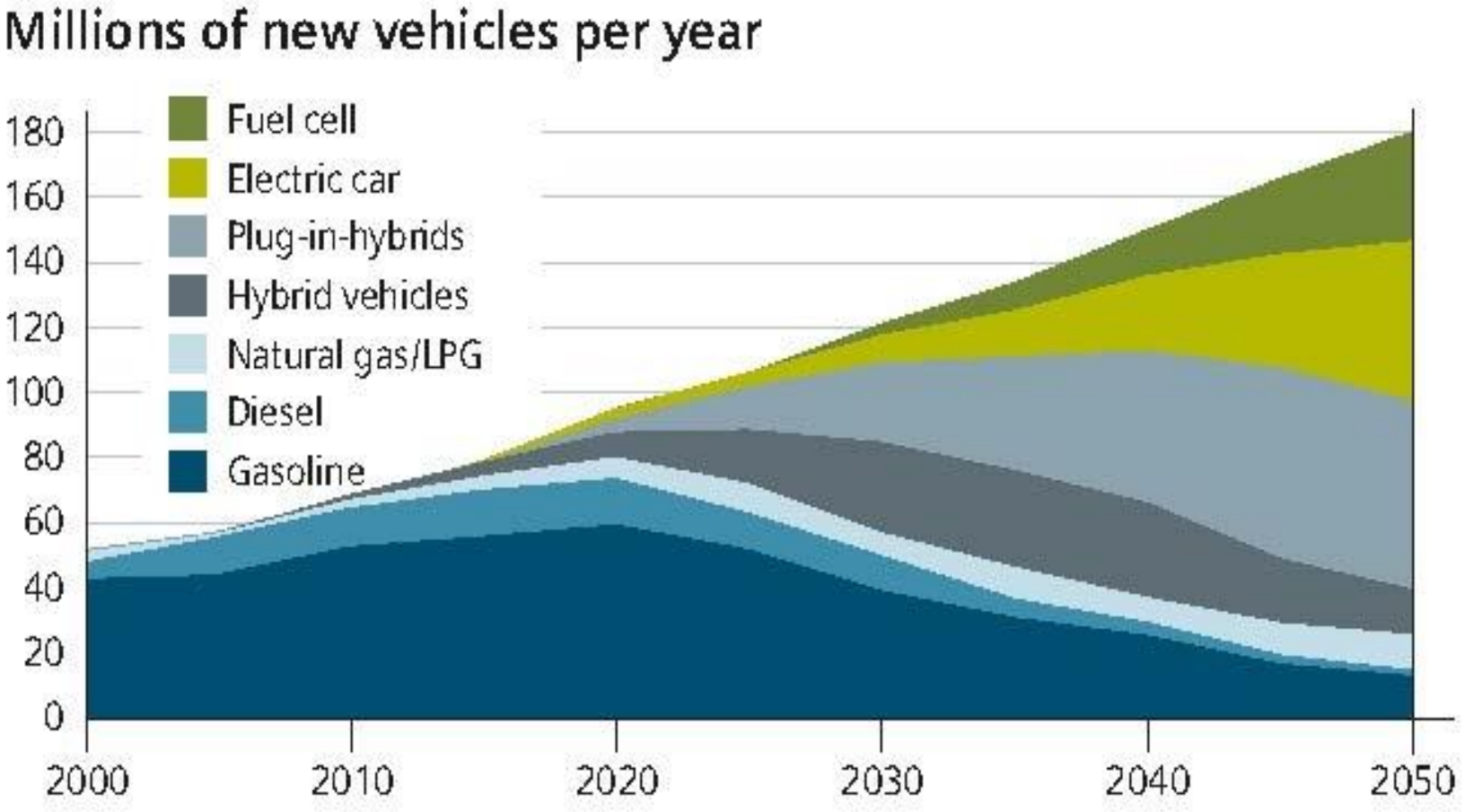
Sparks fly

Battery electric vehicles, worldwide



Sources: Exane BNP Paribas; UBS

Electric Drives Are Expected to Dominate the World Market by 2030



Source: International Energy Agency (IEA)

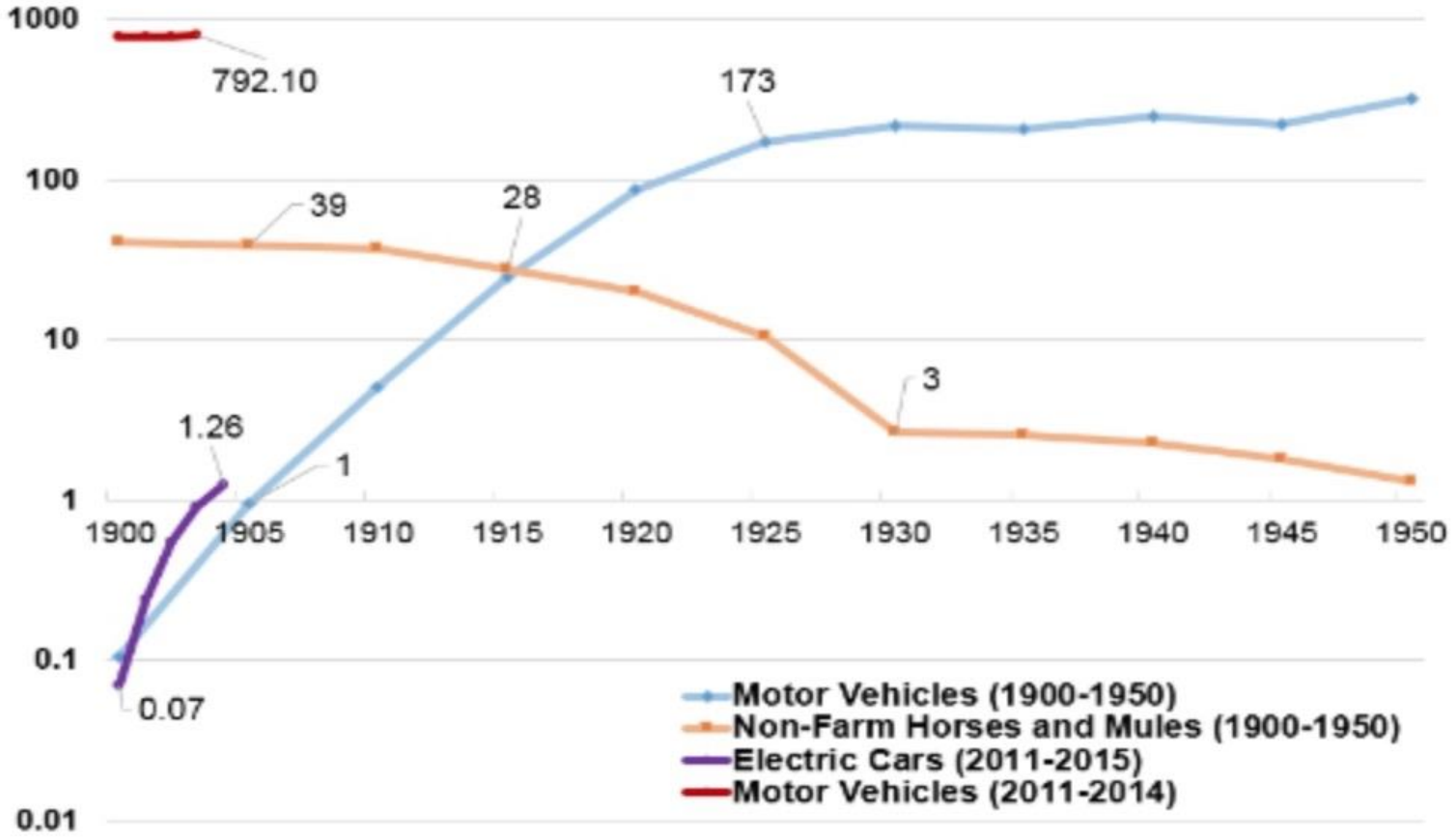
5th avenue, New York, 1900

The great **horse manure** crises

5th avenue, New York, 1913

Just as motor vehicles displaced horses a century ago, electric cars could replace motor vehicles in the next 10 to 25 years.

(per thousand people, log scale)



Note: Electric car graph line starts in 2011.

Source: Cherif, Reda, Fuad Hasanov, and Aditya Pande, 2017, "Riding the Energy Transition: Oil Beyond 2040," IMF Working Paper 17/120.

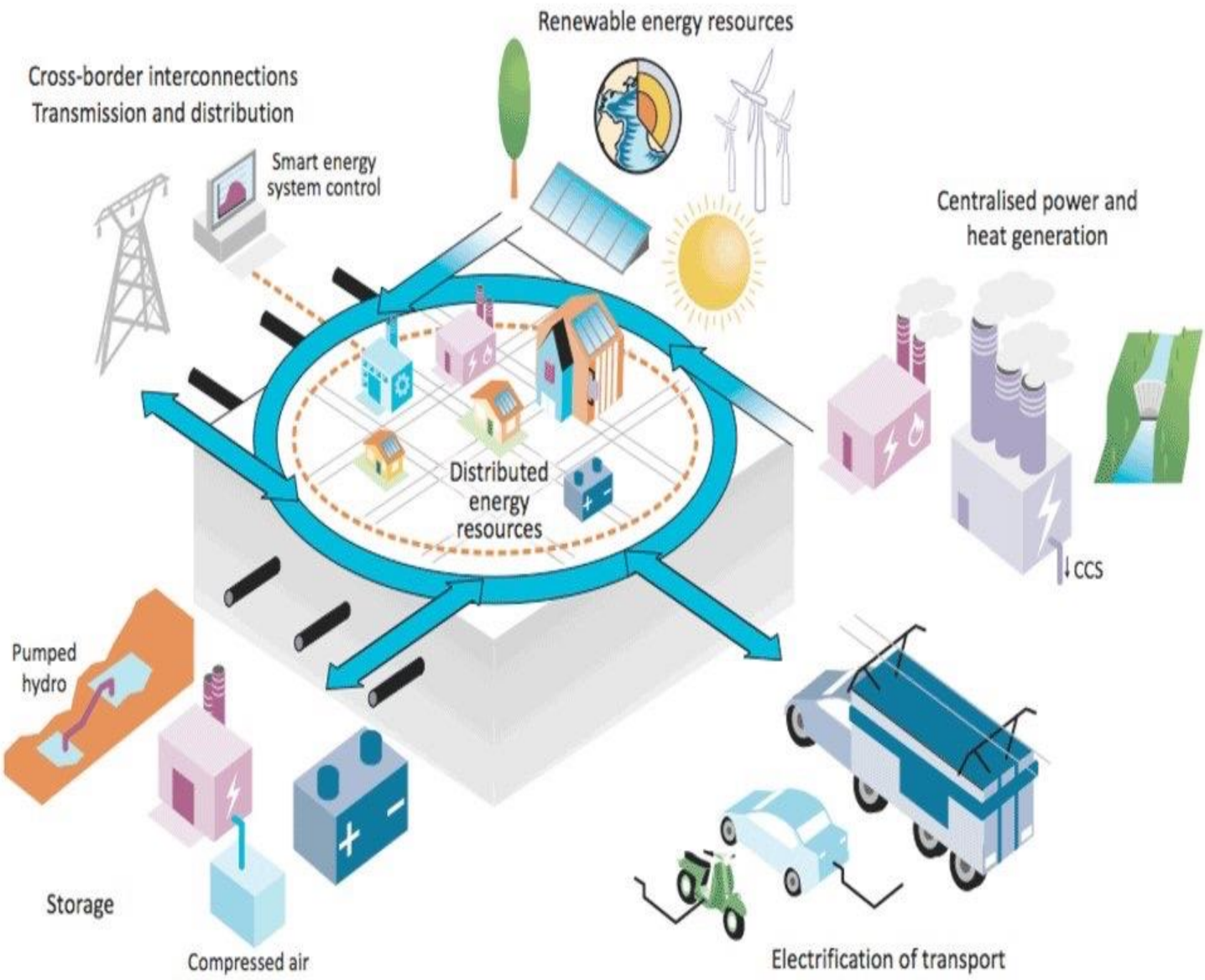
The bottom line

- R327 per GJ for petrol ➔ 312km **= 100c/km**
- R177 per GJ for electricity ➔ 1’852km **= 10c/km**

Future commuter:

  - Light RE-EV, Connected, Autonomous, Shared
  - R177**?** per GJ for electricity ➔ 5’556km **= 5c/km**

Smart distribution grids at the heart of a transformed power system



PRIME NUMBERS

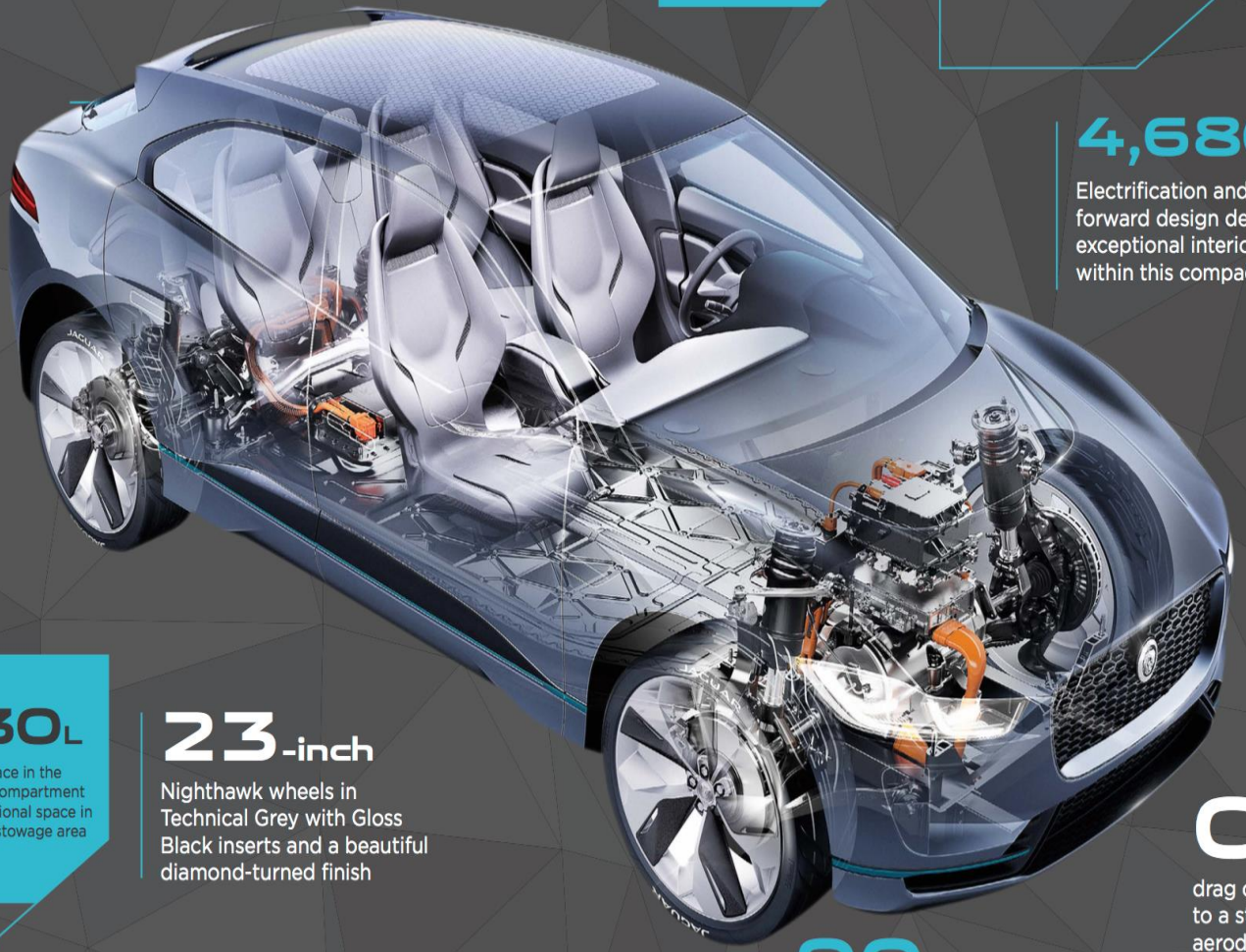
All the key facts about the I-PACE Concept

0-60mph
takes around **4 SECONDS**

12inch
high-resolution Interactive Driver Display replaces conventional dials

400PS
Total power output from the front and rear electric motors

500+
kilometre range achieved on a single charge (EU NEDC cycle)



4,680mm
Electrification and the cab-forward design delivers exceptional interior space within this compact length

ZERO
TAILPIPE EMISSIONS

90
MINUTES
Time taken to achieve 80% charge using 50kW DC charging

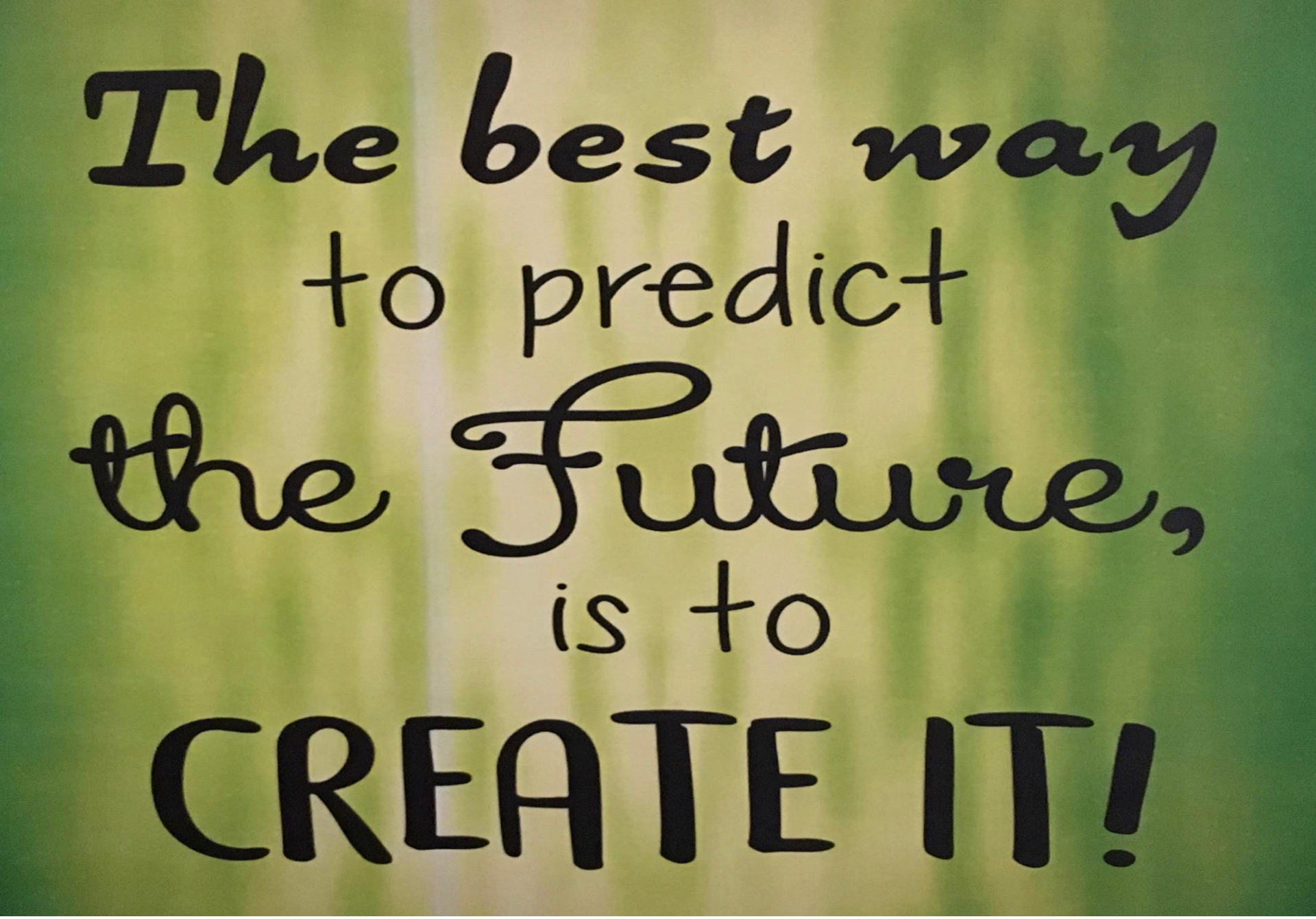
700Nm
of instant, 100 per cent torque for electrifying performance

530L
of loadspace in the luggage compartment plus additional space in the front stowage area

23-inch
Nighthawk wheels in Technical Grey with Gloss Black inserts and a beautiful diamond-turned finish

90kWh
Lithium-ion battery pack, designed and developed by Jaguar Land Rover

0.29Cd
drag coefficient thanks to a streamlined profile, aerodynamically-optimised rear-end design and details such as the flush door handles



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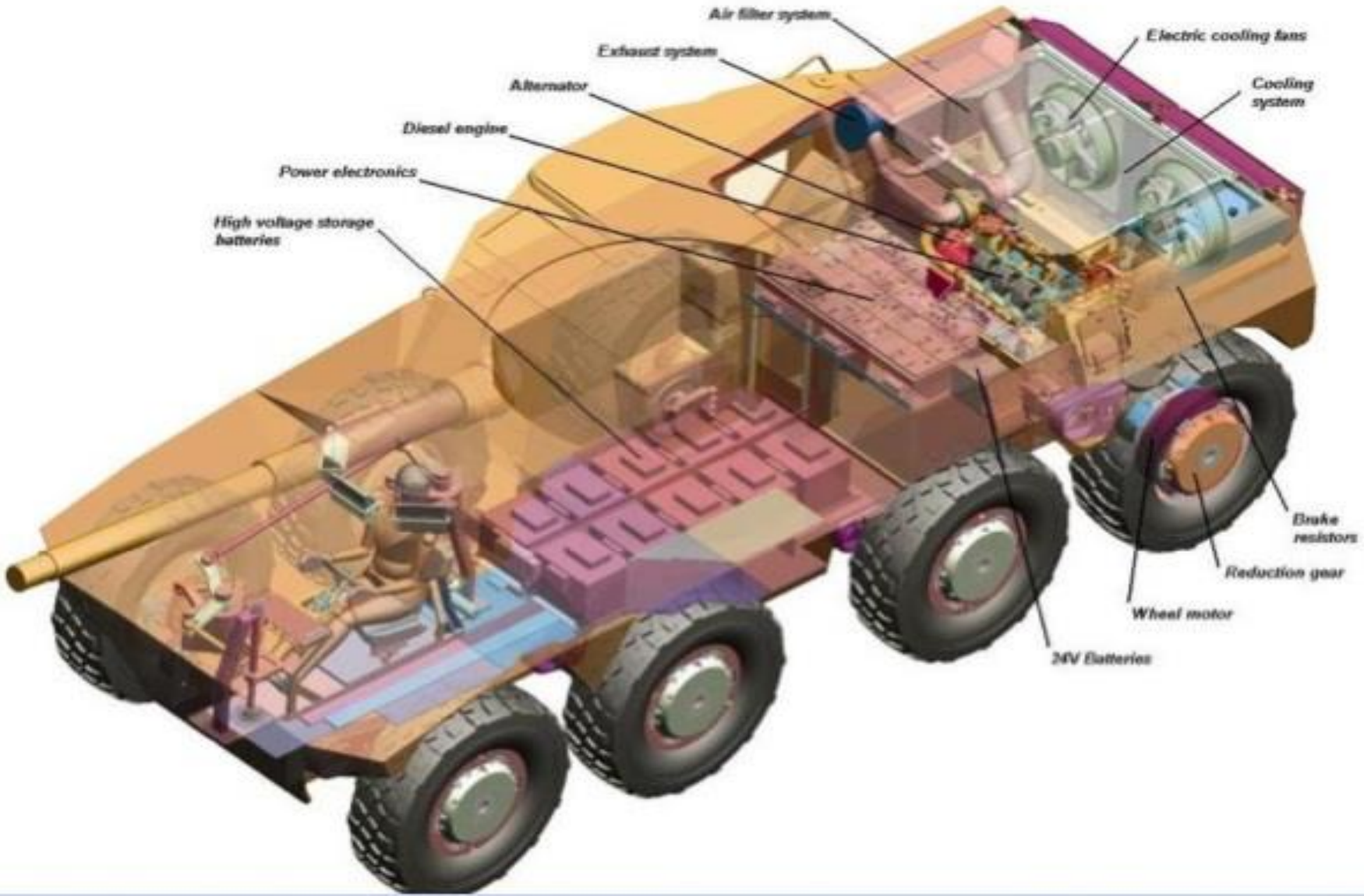
Electric game viewer


Electric game
viewing by
NISSAN/ESKOM
CUSTOS NATURAE

Combat Vehicle Hybrid Electric

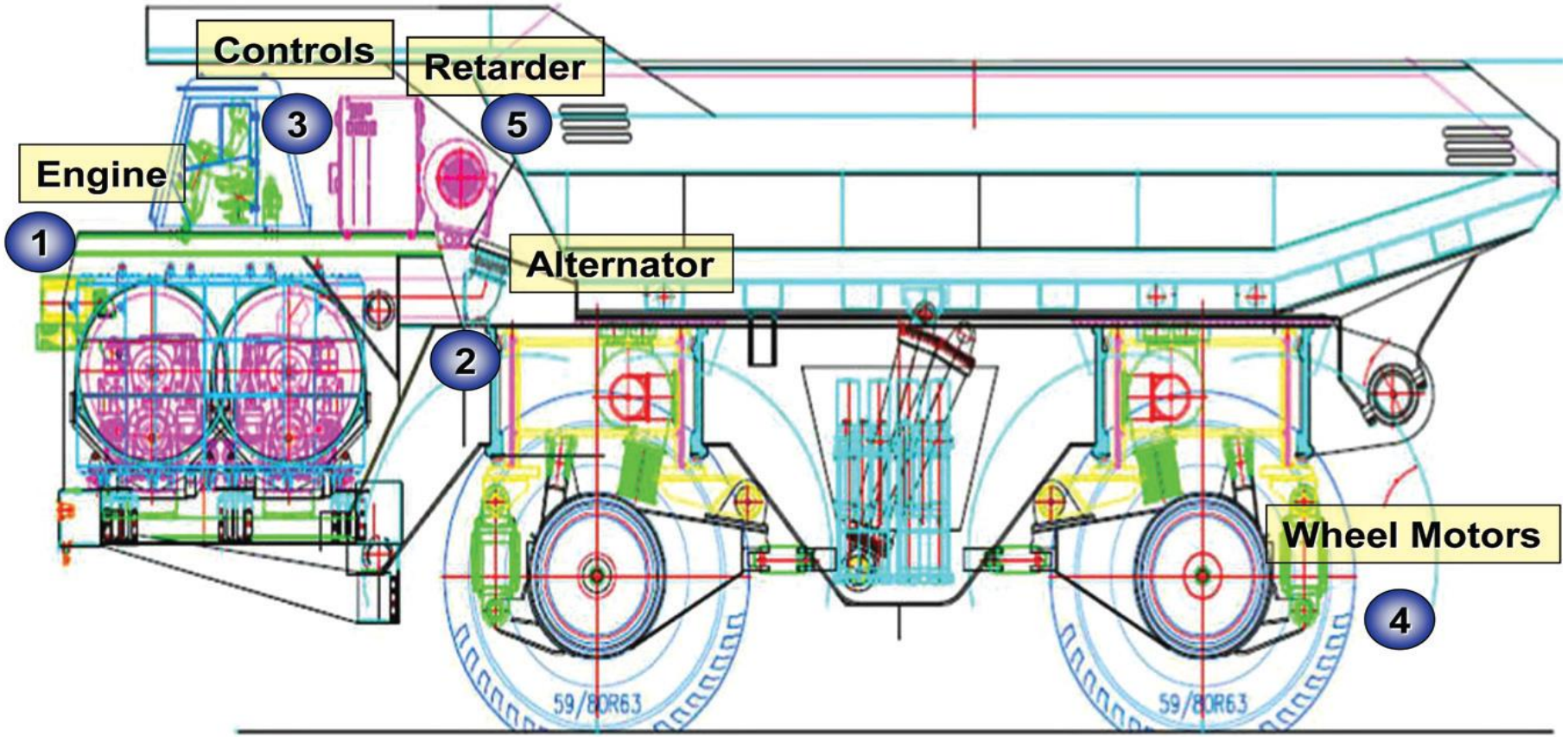



K9

electric 30 Ton rock hauler


797
797 CAT

Technology of Haul Truck (500ton)




860E

Real life examples


SCANIA
G360
SIEMENS


Ich bin die Zukunft!

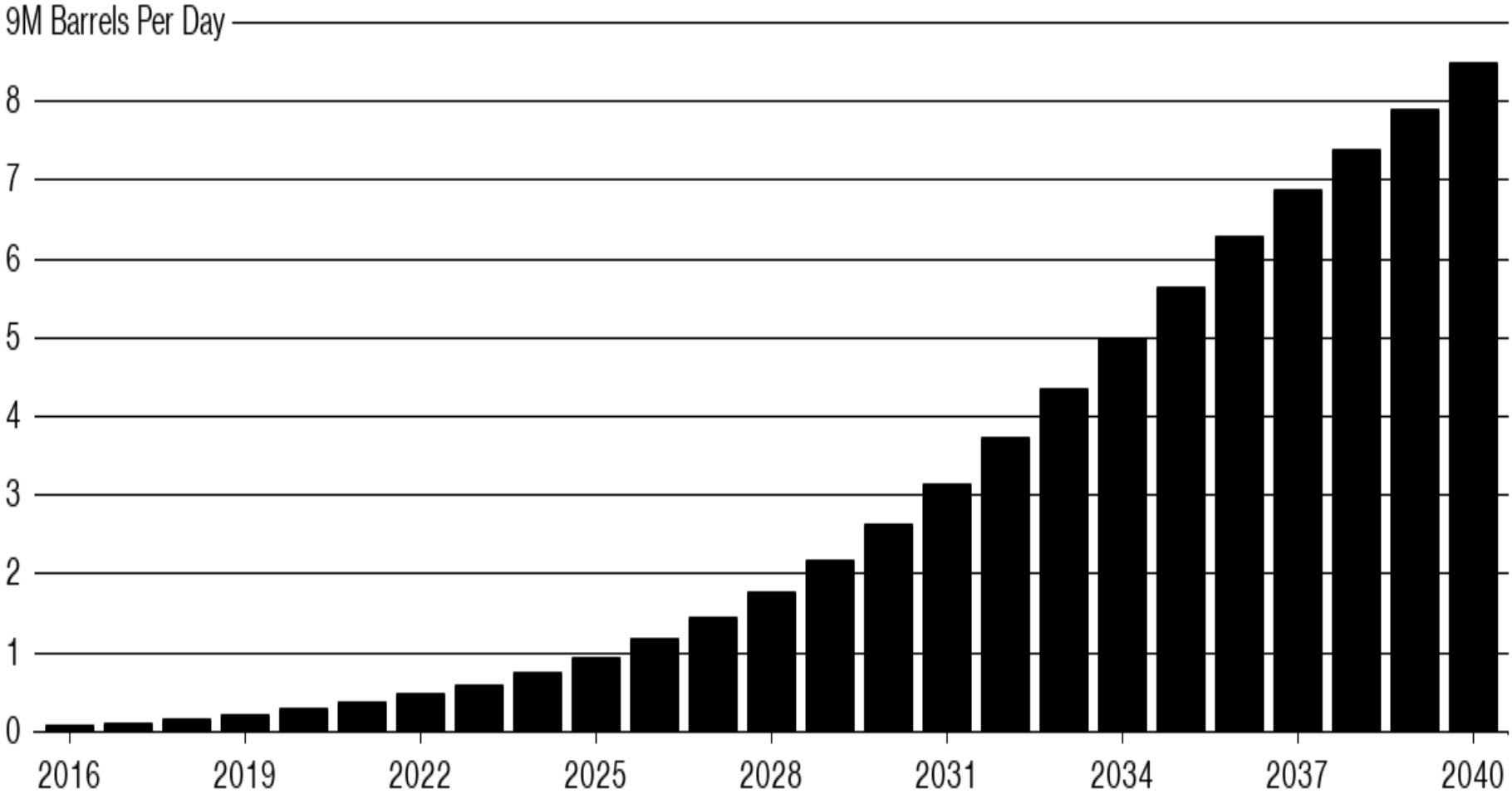

JOHN DEERE

Bloomberg New Energy Finance:

- ✓ In just eight years, Evs will be as cheap as gasoline vehicles, pushing the global fleet to 530million vehicles by 2040
- ✓ Electricity consumption from EVs will grow to 1,8PWh in 2040, or 5% of global power demand, from 6TWh in 2016
- ✓ There's around 90GWh of EV lithium-ion battery manufacturing capacity online now, and this is set to rise to 270GWh by 2021
- ✓ Charging infrastructure will continue to be an issue with bottlenecks capping growth in key Chinese, U.S. and European markets emerging in the mid-2030s

A Diminished OPEC

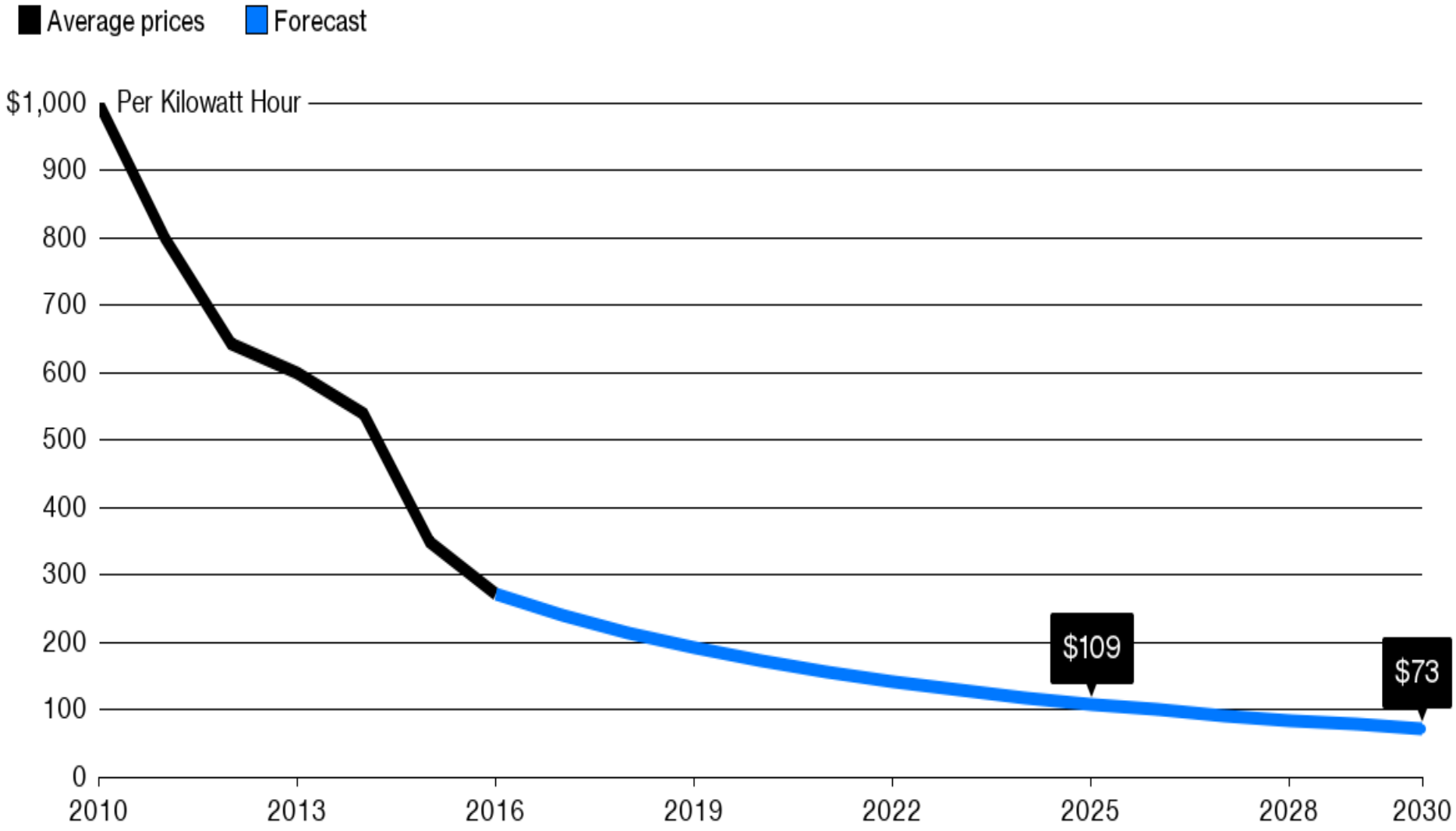
EVs could cut 8 million barrels of use, or 25% of current OPEC output



Source: Bloomberg New Energy Finance

More Bang for Your Buck

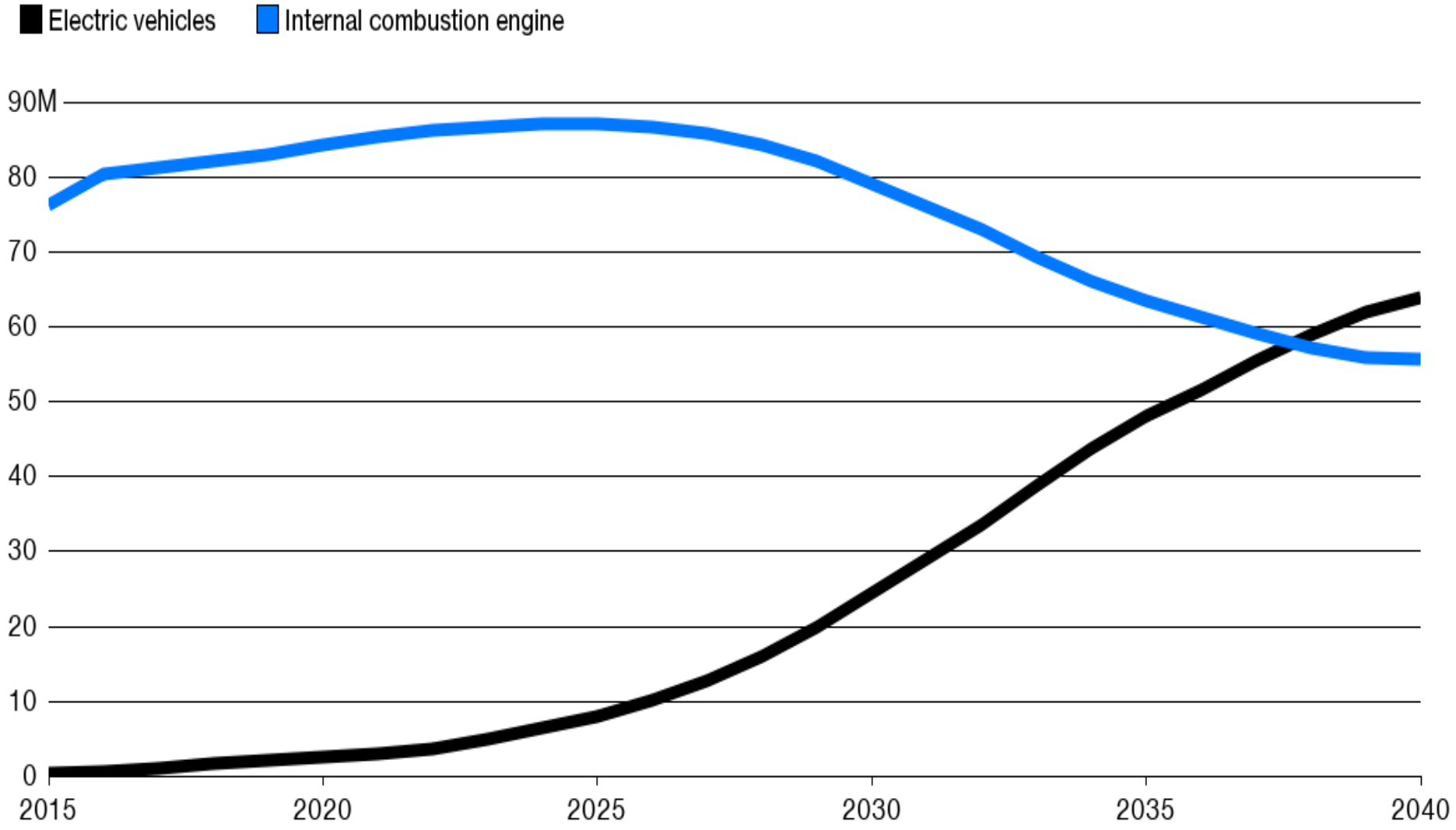
Greater efficiency means a $1,000 battery in 2010 will cost $73 in 2030



Source: Bloomberg New Energy Finance

Overtaking Lane

Electric vehicle sales will surpass internal combustion engine sales by 2038



Source: Bloomberg New Energy Finance