FRAMEWORK FOR IMPROVING FUEL EFFICIENCY IN INDIAN TRANSPORTATION SECTOR USING CONTEMPORARY TECHNOLOGY AND IMPACT OF THE SAME ON INDIAN EXCHEQUER

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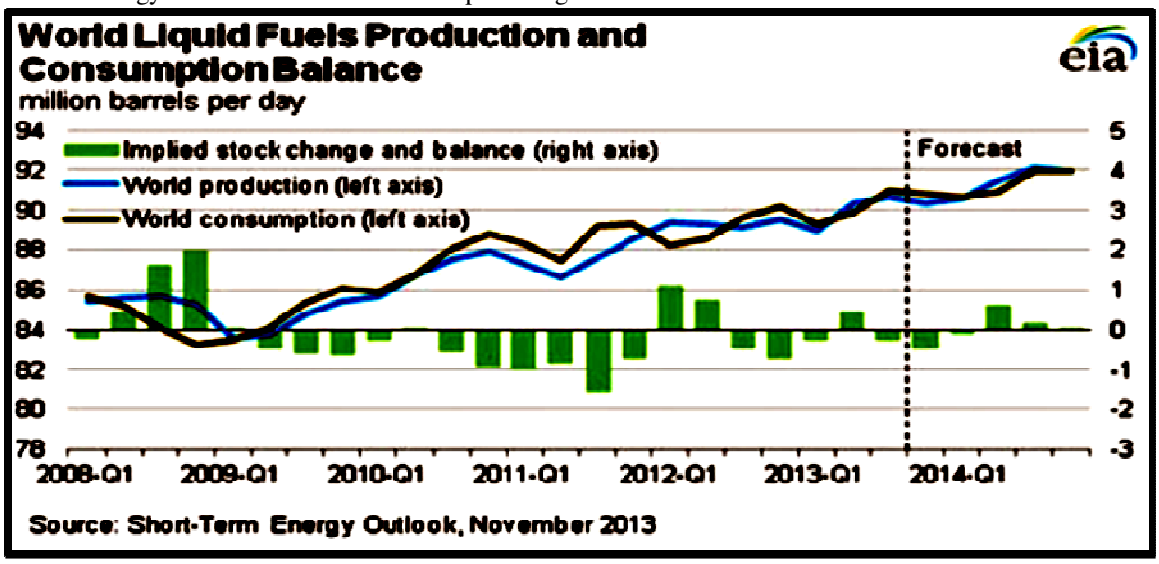
ABSTRACT: *India is highly dependent on imported energy specially the crude. Indian transportation sector is heavy consumer of motor spirit and high speed diesel oil. This paper analyses the import export gap in petroleum products, the consumption patterns of Indian transportation sector as well as exploring means of minimizing wasteful consumption of valuable energy. As part of analysis, the losses in automobiles such as engine losses, transmission losses as well as friction losses are analyzed. Factors which pertain to driving behavior and condition of the vehicles are vital for minimizing consumption. A recommendation is made for eliminating wasteful consumption due to frictional losses such as low tire pressure, idling losses etc., through a framework of sensors and On Board Computer and Diagnostics and vehicle to infrastructure communication system which can monitor and recommend ideal driving behavior resulting in savings in imports of crude. The savings based on the data available is worked out and presented as study findings.*

KEY WORDS : Fuel Efficiency, Tire Pressure Monitoring, Vehicle To Infrastructure Communication, Big Data System, Engine Losses, Transmission Losses, Friction Losses, Indian Crude Imports, Framework For Fuel Efficiency Gain In Vehicles.

1. Introduction

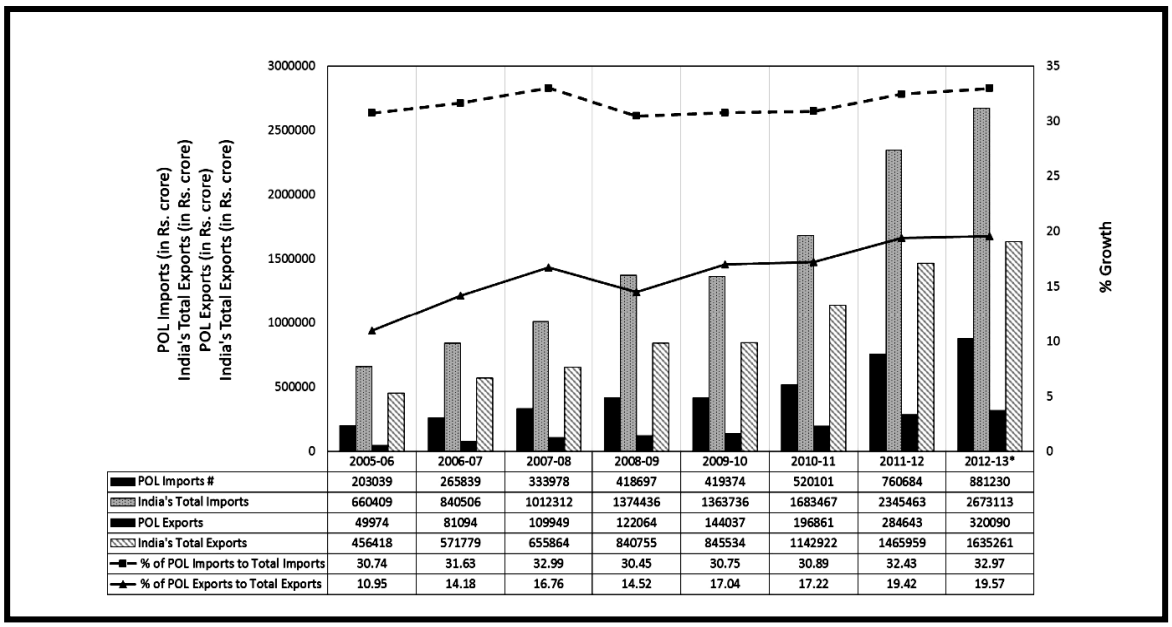
It is well known that the conventional energy made up of fossil fuel has a finite supply. It is not known yet for how long will we be able to source the conventional source of energy such as Oil and Gas, but it is fair to consider that the current known sources would last approximately 70 to 80 years at the current rate of consumption extrapolated for Moderate growth. The day is not far when the entire mankind would be closely controlling the way of consumption of the conventional energy, at least till such time we do not have any alternatives and discovery of credible unconventional sources of energy. The short term balance is as per the figure 1 below.



(Figure 1: Global Production and Consumption Balance)

The Indian economy is at a critical stage of development. During 2012-13, the growth rate of Gross Domestic Product (GDP) at current prices increased by 5%, with Industry at 2.1%, Services at 7.1% and Agriculture at 1.9%. There has been an overall slowdown since 2010-11 when GDP increased by 9.3% and declined to 6.2% in 2011-12. As against the overall trend in growth of the Indian economy, the energy requirement continued to increase during this phase. Given the limited domestic availability of oil and gas, the country is compelled to import over 75% of its domestic requirement. Imports of petroleum products during 2012 – 13, was 15.774 MMT valued at Rs. 68, 363 crores & US$ 12,506 Million, which marked a decrease 0.47 % in quantity but increased by 0.40% in value terms in Indian Rupees lower by 11.86% in Dollar terms.

As may be noted, our country loses enormous amount of foreign exchange on importing petroleum products. It is important to know that the country's precious foreign exchange reserves get consumed just on POL imports which are staggering 32.97% of total imports of the country. This can be seen from the below graph 1.

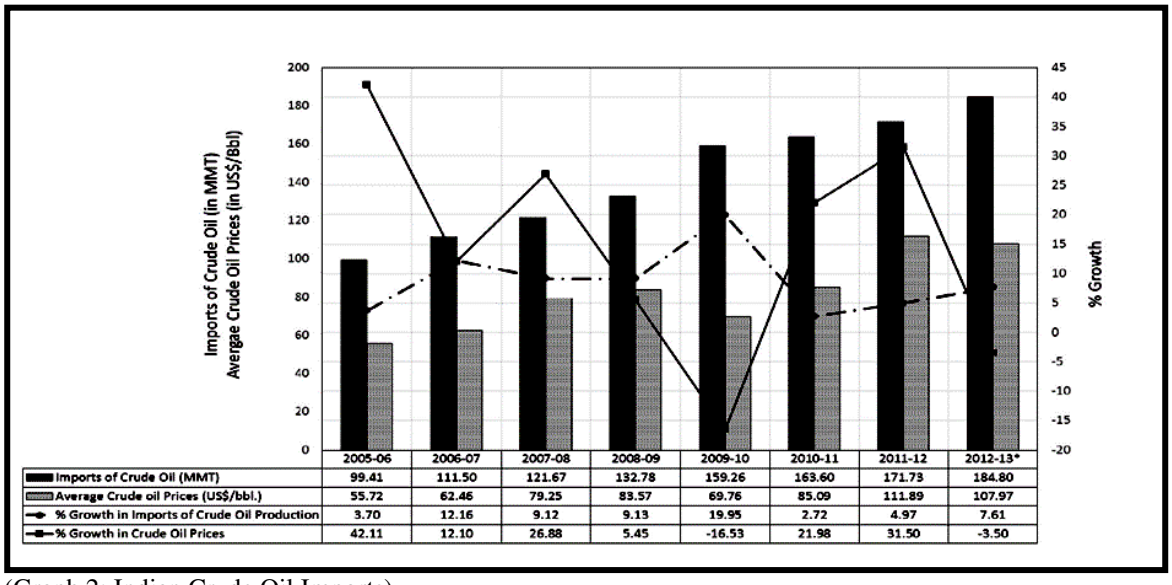


	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13*
POL Imports #	203039	265839	333978	418697	419374	520101	760684	881230
India's Total Imports	660409	840506	1012312	1374436	1363736	1683467	2345463	2673113
POL Exports	49974	81094	109949	122064	144037	196861	284643	320090
India's Total Exports	456418	571779	655864	840755	845534	1142922	1465959	1635261
% of POL Imports to Total Imports	30.74	31.63	32.99	30.45	30.75	30.89	32.43	32.97
% of POL Exports to Total Exports	10.95	14.18	16.76	14.52	17.04	17.22	19.42	19.57

(Graph 1: POL Imports)

The most significant import is the Crude Oil imports which has been impacting India's economy adversely is import of Crude Oil. As can be seen from below graph, the import of crude is increasing year after year and for a growing economy such as India, the energy needs are bound to be high.

Following graph 2 summarizes India's Crude Oil imports along with average crude price for previous financial years.



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13*
Imports of Crude Oil (MMT)	99.41	111.50	121.67	132.78	159.26	163.60	171.73	184.80
Average Crude oil Prices (US$/bbl.)	55.72	62.46	79.25	83.57	69.76	85.09	111.89	107.97
% Growth in Imports of Crude Oil Production	3.70	12.16	9.12	9.13	19.95	2.72	4.97	7.61
% Growth in Crude Oil Prices	42.11	12.10	26.88	5.45	-16.53	21.98	31.50	-3.50

(Graph 2: Indian Crude Oil Imports)

Apart from India losing such a precious dollars on importing Crude, India also ends up giving subsidy to consumers. The total subsidy during 2012-13 provided by Government of India & Oil companies on Kerosene and LPG were Rs.30, 151 & Rs.41, 547 crore respectively and
these marked increase by 6.86% & 29.29% against subsidies of Rs.28, 215 & Rs.32, 134 crore respectively during 2011-12.
The consumption of POL products is as per the table 1 below:

	Products	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13*	% Growth 2012-13/ 2011-12
	1	2	3	4	5	6	7	8	9	10
1	**Light Distillates**	**33662**	**37075**	**38557**	**39878**	**38995**	**41443**	**43870**	**46351**	**5.7**
	of which									
	LPG	10456	10849	12165	12344	13135	14331	15350	15605	**1.7**
	Motor Spirit	8647	9285	10332	11258	12818	14194	14992	15744	**5.0**
	Naphtha+NGL	12194	13886	13294	13911	10134	10676	11222	12342	**10.0**
	Others	2365	3055	2766	2365	2908	2242	2306	2660	**15.3**
2	**Middle Distillates**	**54423**	**57595**	**62823**	**66378**	**71120**	**75029**	**79415**	**82795**	**4.3**
	of which									
	SKO	9541	9505	9365	9303	9304	8928	8229	7502	**-8.8**
	ATF	3296	3983	4543	4423	4627	5078	5536	5270	**-4.8**
	HSDO	40191	42896	47669	51710	56242	60071	64750	69174	**6.8**
	LDO	883	720	667	552	457	455	415	399	**-3.8**
	Others	512	491	579	390	490	497	485	450	**-7.3**
3	**Heavy Ends**	**25129**	**26078**	**27568**	**27343**	**27693**	**24568**	**24847**	**27382**	**10.2**
	of which									
	Furnace Oil	8921	9257	9469	9419	9145	8807	7548	6317	**-16.3**
	LSHS	3907	3361	3248	3169	2484	1982	1759	1366	**-22.3**
	Lubes/Greases	2081	1900	2290	2000	2539	2429	2633	2685	**2.0**
	Bitumen	3508	3833	4506	4747	4934	4536	4638	4658	**0.4**
	Petroleum Coke	4928	5441	5950	6166	6586	4982	6138	9947	**62.1**
	Paraffin Wax	268	303	241	203	211	198	211	228	**8.2**
	Other Waxes	105	64	65	65	78	56	58	79	**35.4**
	Others	1411	1919	1799	1574	1716	1578	1863	2103	**12.9**
	TOTAL	**113214**	**120748**	**128948**	**133599**	**137808**	**141040**	**148132**	**156528**	**5.7**
	% age growth	**1.4**	**6.7**	**6.8**	**3.6**	**3.2**	**2.3**	**5.0**	**5.7**	

* :Provisional and not included data in respect of RIL SEZ Refinery as it is presumed that all products have been exported and not consumed domestically.

(Table 1: Consumption of POL Products)

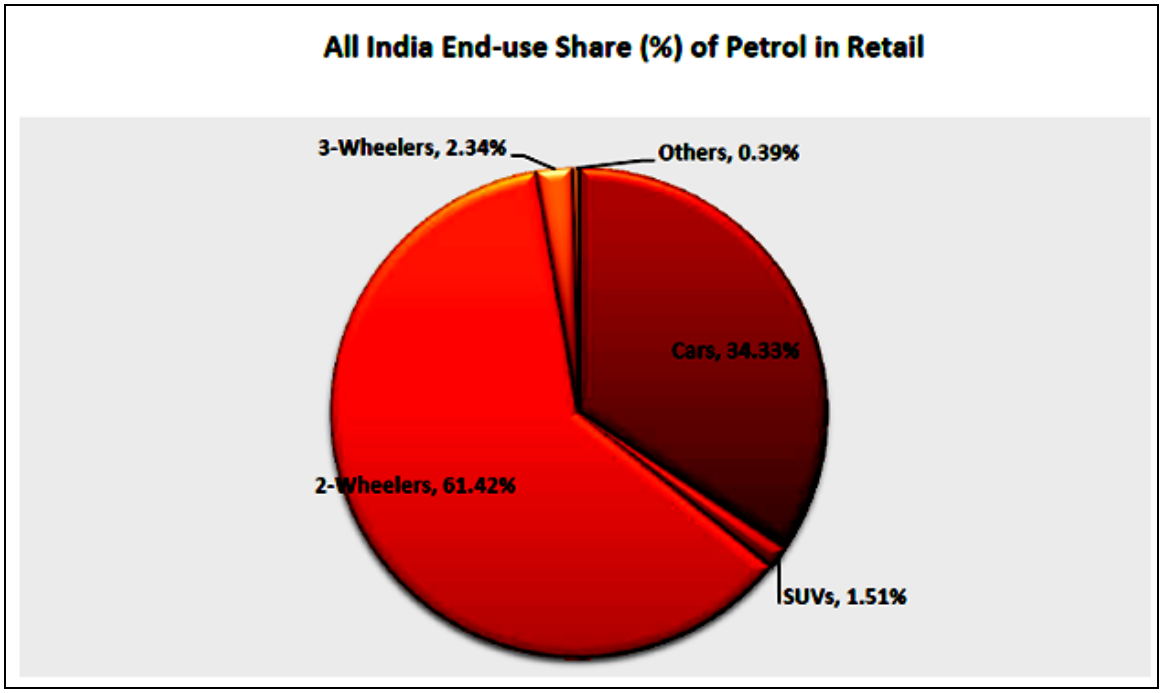
Amongst all the products we have as above, Motor Spirit is only used for the private vehicles while High speed Diesel oil is used for transportation as well as for running diesel generators, pumps and agricultural areas.

2. Fuel Consumption in Transportation Sector

The above table gives the information about consumption of Motor Spirit (popularly known as Petrol) and High Speed Diesel Oil being consumed in the country.

Motor Spirit

Based on the table above, it can be known that the Motor Spirit consumption, which is almost entirely, needed for private vehicles comprising of 2 wheelers, 3 wheelers and 4 wheelers. The total consumption is 15744, 000 tonnes. The breakup of the consumption by the types of vehicle is given in the Figure 2:

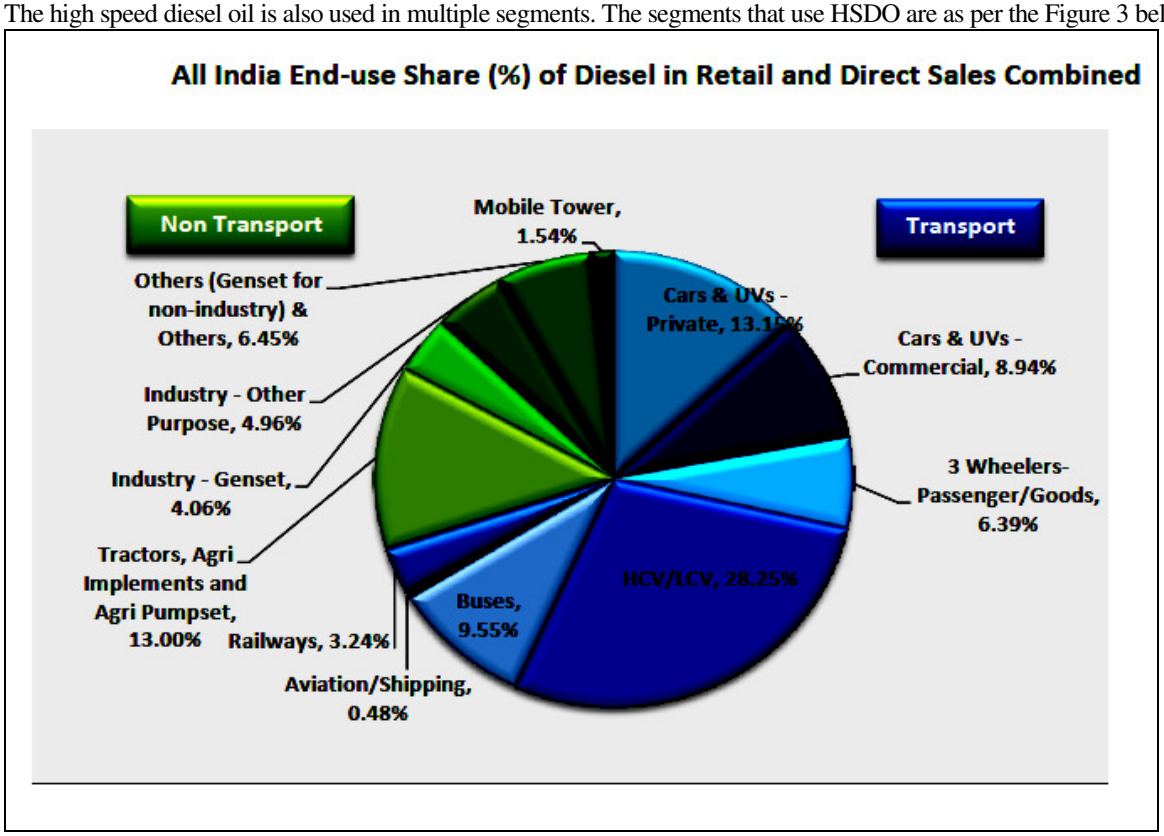


(Figure 2: All India End-Use share of Petrol)

At an All India level study reveals that 2-wheelers segment accounts for the highest consumption of Petrol at 61.42% while Car category contributes for 34% of retail petrol consumption. It is interesting to note, 2-wheeler and cars together account for 95% of the total consumption of petrol (retail sales) in India.

High Speed Diesel Oil

The high speed diesel oil is also used in multiple segments. The segments that use HSDO are as per the Figure 3 below:



(Figure 3: All India End-Use share of Diesel)

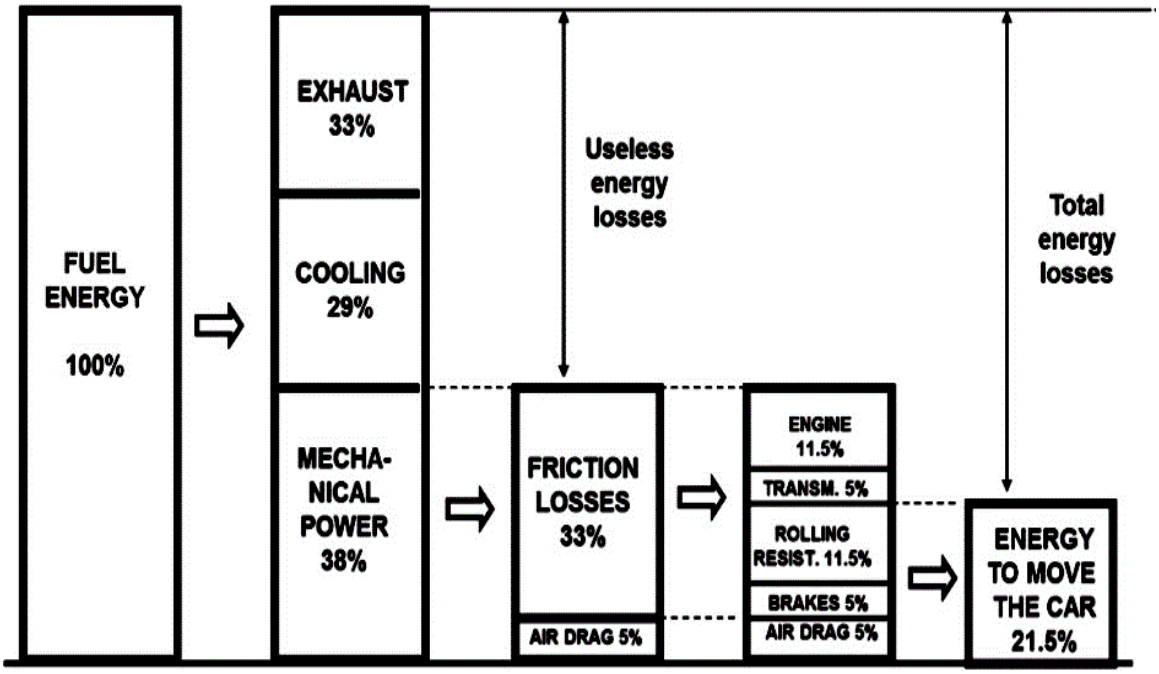
As can be noted from the graph above that transport sector accounts for 70% (both direct and retail sales) consumption of diesel at all India level; LCVs, HCVs and Buses together account for about 38%. This is due to, the large distances that are travelled by commercial vehicles vis-à-vis passenger vehicles. Cars and UVs category contribute nearly 22% of

the diesel sales, in which private vehicle consumes little less than 60% of total in this category. This huge private consumption of diesel is due to growing population of UVs and cars, especially amongst private car owners. This segment is expected to grow very fast due to introduction of new generation fuel efficient vehicles by different vehicle manufacturers. Also change in consumer attitude of a particular segment to opt for UVs rather than conventional cars. However, it is interesting to note that there is significant diesel consumption in commercial car and UV segment. Agriculture sector accounts for around 13%. Agri-implements largely stand for Tractor based agri-equipment such as Harvesters, Threshers, etc.

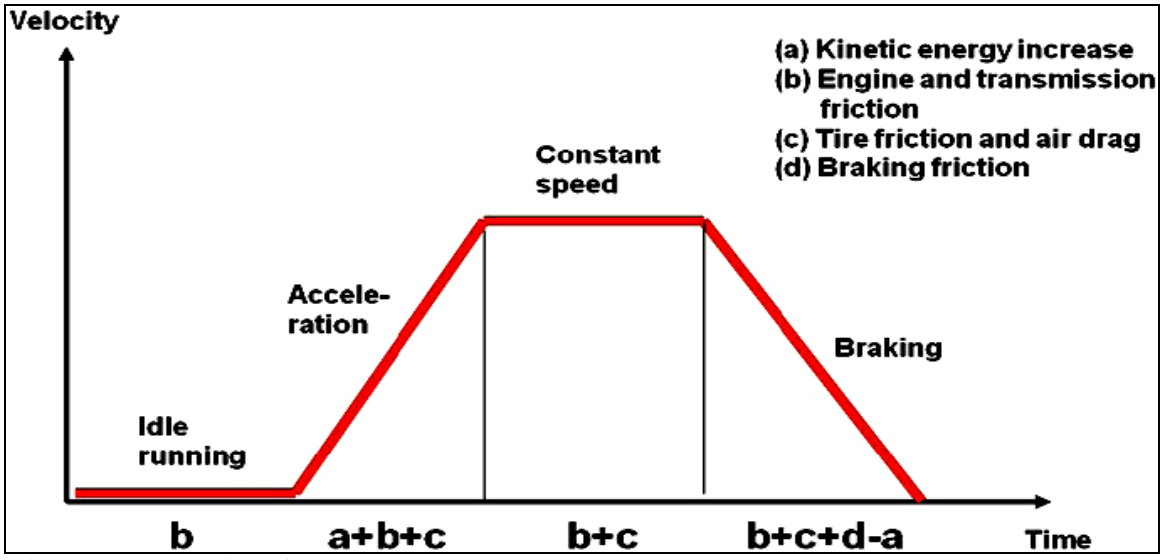
3. FACTORS IMPACTING TRANSPORTATION EFFICIENCY

There has been a massive amount of research already conducted in the subject of Fuel Efficiencies of automobiles. The energy lost in automotive transmission is significant and the actual useful work output of the car is approximately 20% of the actual energy consumed in the internal combustion engine by burning of fuel. Following Figure 4 depicts the typical losses and useful work output of vehicle:

The pattern of the losses during the vehicle being idle state accelerating to a steady state motion and then decelerating again back to idle state is mapped on Time Vs Speed curve as per the Figure 5 below. It must be noted that despite car being in idle state engine and transmission losses will still be applicable and the vehicle will continue to consume energy without delivering any useful work output.



(Figure 4: Typical Automobile Losses)



(Figure 5: Consumption of Energy)

India despite being highly import dependent in terms of its energy need, has very inefficient track record of vehicle maintenance and driving conditions. It has been observed that the vehicles are poorly maintained and factors which are critical to giving us higher fuel efficiency and throughput are not complied with. Many of the recommendations which are essential to gaining healthy mileage such as inflated tires, tire stops and starts etc. are not complied most of the times. With the Information Technology and Network communications improving, there are several areas that were hereto not measurable or not controllable, can actually be measured resulting in substantial improvement in fuel consumption as explained in this report.

4. LEVERAGING INFORMATION TECHNOLOGY FOR SUPPLIER FUEL CONSUMPTION

Based on the research work carried out in the automotive industry for fuel efficiency improvements, following table identifies parameters that impact the vehicle efficiency and also if Information Technology can be leveraged for reducing the overall consumption of fuel.

This paper proposes a solution to monitor the parameters pertaining to Eco driving stated above and recommendation on bringing in governance around these parameters for superior fuel efficiency.

Sr No	Description	Energy Losses - Typical Values
Engine and Drive Related		
1	Exhaust Gases	30-37%
2	Cooling	25-33%
3	Friction Related	App 33% with foll. Distribution
3.1	Air Drag	3-12%
3.2	Tire Road Contact	12-45%
3.3	Friction in Engine System	30-35%
	Piston Assembly	
	Bearings and Seals	
	Valve Train	
	Pumping and Hydraulic viscous losses	
3.4	Friction in transmission System	7-18%
	Viscous losses in oil tank, gear contact	
	Friction in gears	
	Friction in bearings	
	Friction in seals, forks	
3.5	Brake contact	10-18%
Factors Linked to Eco Driving resulting in Improved Fuel Consumption		
1	**Idle driving**	**Proposed Solution Based on Modern Contemporary techniques in IT**
2	**Start Stop**	
3	**Condition of Tires and road contact**	
4	**Controlled acceleration and Deceleration**	
5	**Smart Driving**	

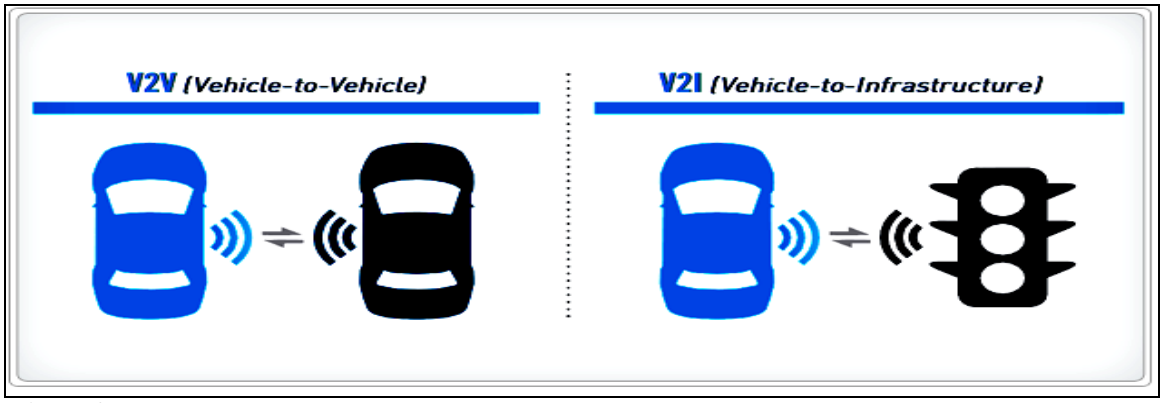
(Table 2: Factors Impacting Fuel Consumption)

5. PROPOSED IT SOLUTION

The proposed framework is to leverage contemporary technology for bringing fuel efficiency. This includes using an "On Board Computer and Diagnostic (OBCD) system". The functionality of the OBCD would be to monitor, track, and record the driving habits and ability to certify the driver based on "Eco Friendly Driving Score" technique.

Vehicle to Vehicle/Vehicle to Infrastructure Communication

Particularly Vehicle to Infrastructure such as traffic lights can result in substantial benefit in achieving the objective of "Smart Driving". This can help the driver to fine tune his vehicle speed in such a manner that the idle running and deceleration/acceleration can be eliminated completely.



(Figure 6: VoV / VoI)

On Board Computer and Diagnostics Measurements and controls

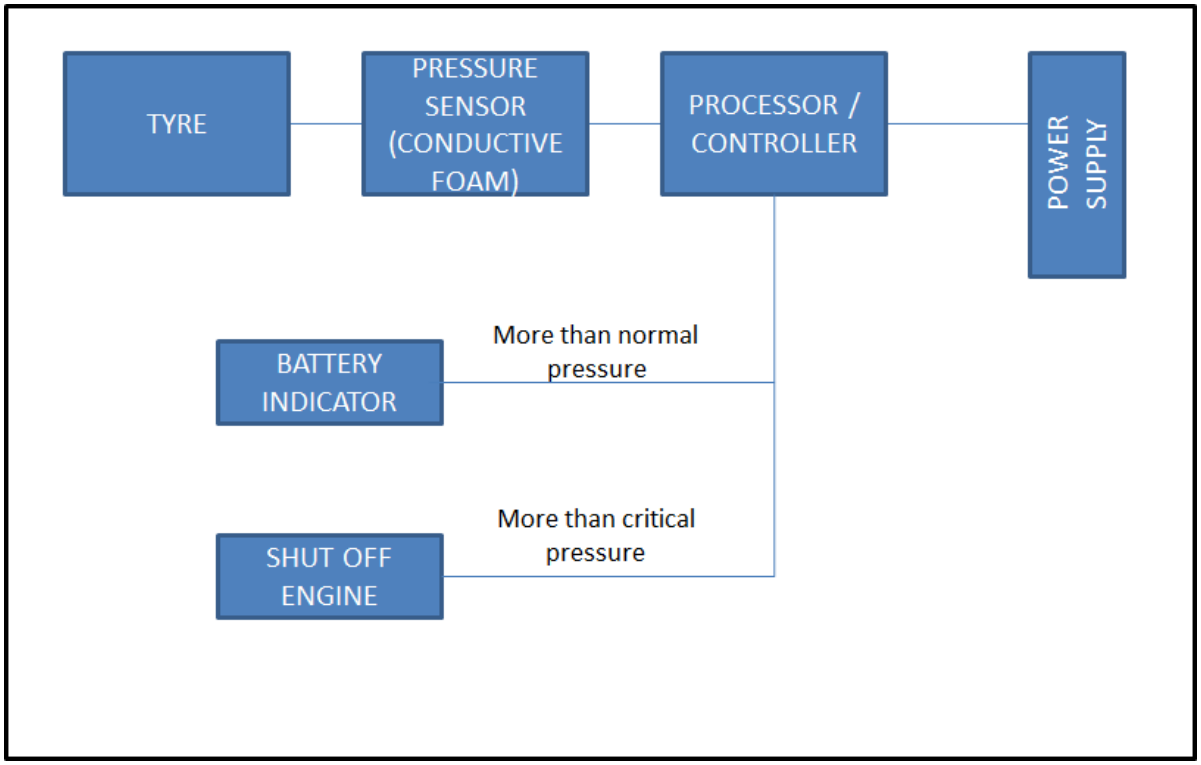
The On Board Computer can sensitise the driver on multiple factors such as:

-**Idle Running:** Even during engine idling, the friction and transmission losses consume fuel. Eco driving monitoring can measure the idle running of the vehicles without being in motion and capture the same in their OBCD. The total idle time and the loss of fuel due to idle running can be computed.

Smart Idle Stop system: Stop- Start technology was used by Volkswagen in 1990s using 12-V system that shuts off engine when vehicle comes to full stop and restarts the engine when the driver taps the accelerator pedal. These systems have potential of improving fuel economy of cars by 5 to 8 % and reducing simultaneously the idle emissions. Other more sophisticated systems termed as 'SISS (Smart Idle Stop System)' have been developed that make the engine to start at mid- piston stroke so that minimum restarting torque is required. SISS reduced fuel consumption by 8% on ECE 15 cycle based on the tests conducted.

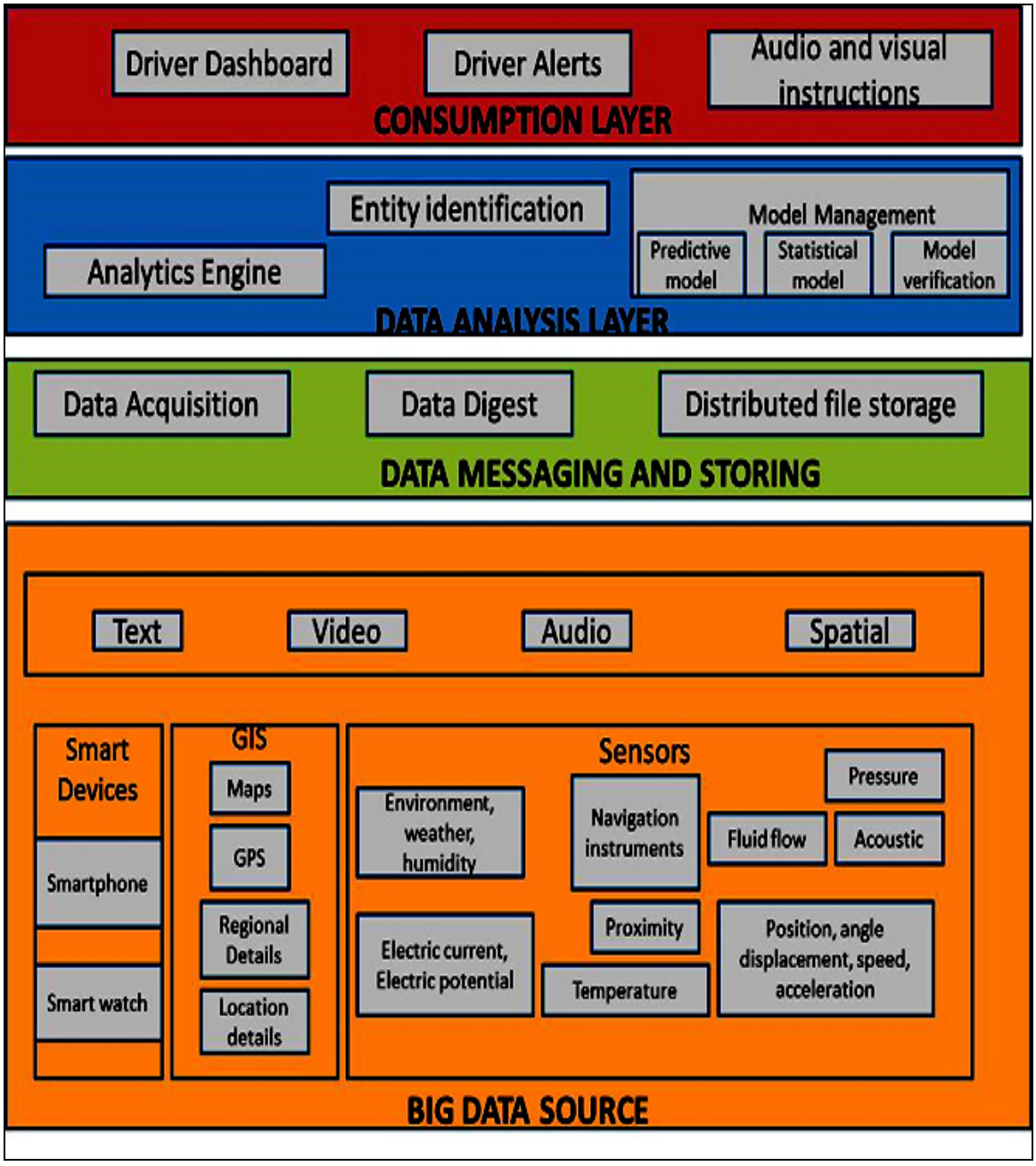
Tire Air Pressure monitoring system: During the last five decades, car tires have been subjected to advanced product development; however, very little information is available about them in the open literature. Part of the development work has been focused on reduction of the rolling resistance. A 10% reduction in rolling resistance corresponds to a 2% reduction in energy demand, or a 2% reduction in fuel consumption. As per the statistics, approximately 50% vehicles are run with tire pressures less than the optimum

Based on Automotive Research Society of India (ARAI), tire pressure monitoring system can help improve the fuel efficiency by 3-5%. The system would be as per the figure given below:



(Figure 7: Tyre Pressure System)

Controlled acceleration and deceleration: The acceleration and deceleration consume considerable fuel and results into generating unnecessary torque. The OBCD can capture such information and sensitize the drover about need for smoother acceleration and deceleration for saving fuel. The entire data processing of the computer can be captured into a "Big Data" analytics to get "Driving Behavior" and "Eco Friendly Driving Score". The architecture will be as below:



(Figure 8: Architecture)

6. CALCULATIONS OF SAVINGS DUE TO GAIN IN FUEL EFFICIENCY:

Based on the statistics available, the detailed computation worked out for the benefits just due to one single parameter of "Tire Pressure efficiency gains". Based on the survey, 10% reduction in tire pressure would result in 2% efficiency gain. Applying these calculations, following benefits are derived:

Savings in Petrol (Motor Spirit)

Annual Consumption of Motor Spirit during FY 12-13 as per Government of India Petroleum and Natural Gas Statistics table V 1.(b)= 15744,000 Tonnes

Average consumption of Motor Spirit during FY 12-13 in bbl = 133.824 Million Barrels

Based on average Motor spirit barrels/tonne = 8.5

Average International Crude oil prices (Indian basket) as per Govt

Of India Petroleum and Natural Gas Statistics	=	*107.97 USD/BBl*
Annual Motor Spirit consumption in eqvt of crude	=	*14.44898 Billion USD*
Saving of 2% for 50% of the vehicles	=	*0.1444898 Billion USD*
	=	*INR 788.96 Crores*

Based on USD/Rs of 54.45 as per Indian crude basket

Savings in Diesel

Average consumption of HSDO during FY 12-13 as per Government of India Petroleum and Natural as Statistics table V 1.(b)	=	*69174,000 Tonnes*
Average Consumption in Barrels during FY 12-13	=	*518.805 Million Barrels*
Annual HSDO consumption in eqvt of crude	=	*56.01538 Billion USD*
Savings of 2% of 50% of vehicle with 70% HSDO is for Transportation	=	*INR 2135.026 Crores*

As can be noticed, total reduction in crude consumption of INR 2923.98 Crores can be achieved just due to the appropriate tire pressure. Even if we assume 10% overall reduction due to all other measures (ARAI recommendation of 15%) the net saving of foreign exchange by the Government of India will work out to whopping INR 21350 Crores per year just on account of more controlled and monitored usage of vehicles using contemporary techniques and effectively using the information technology.

7. CONCLUSION

India is a highly import dependent country especially as just about 30% of the country's energy needs are met by indigenous reserves. India's automobile and vehicle driving behaviors is not eco-friendly neither does the same help in minimizing imports. There are several possible options technology provides and based on some simple measures such as motor idling, tire pressure, smart driving the savings could be over INR 2135 crores annually. Government of India through its Gazette provides guidance on the use of vehicles based on contemporary technologies. It is recommended that as use of On Board Computer and Diagnostics can help reduce the consumption of fuel, in turn providing savings to the national exchequer of imports of crude of equivalent amount.

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