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TEG

ON THE DEPLOYMENT OF THERMOELECTRIC WASTE HEAT RECOVERY (TWHR) IN THE MALAYSIAN ROAD TRANSPORT SECTOR

Background

The road transport sector in Malaysia consumes the major portion of energy consumed by all transportation sectors, which represents 63% of the total energy consumption along with industrial sector as of 2005. While in 2002, energy demand for road transport represented 86 % of the total transport energy demand. Indisputably, more than 60% of the fuel energy is lost as waste heat in ICE driven vehicles. This enormous percentage of waste fuel energy charges Malaysia billions of MYR every single year due to the escalating reliance on road transport. Automotive OEM and several research organizations worldwide have been focusing on TWHR systems as possible solutions to recover such huge amounts of waste fuel energy. This paper focuses on investigating the potential energy savings from deploying TWHR systems in the Malaysian road transport sector as well as exploring the prospective investment size

Malaysian Transportation Energy Trends

Malaysia is rich with conventional energy resources such as oil and gas as well as renewables like hydro, biomass and solar energy. The economy is a net energy exporter with 11 % of export earnings in 2004 derived from crude oil, LNG and petroleum products export. The final energy demand of Malaysia is projected to grow at 2.9% per year, reaching 69.39 MTOE in 2020, nearly TWO times the 2002 level. The industry sector will have the highest growth rate of 3.38 %, followed by transport at 2.74%, residential at 1.86% and commercial at 1.14%, as in figure 1.

Malaysia has a relatively high growing rate of passenger vehicle ownership, see figure 2. The recess in the vehicle number growth rate in the period between 1997 and 1999 reflects the economical crisis occurred in that period. However, the escalating number of passenger vehicles over 50 years from 53 vehicles per 1,000 populations in 1980, through 180 vehicles in 2002 to a predicted value of 347 vehicles per 1,000 populations in 2030; reflects the long-term unrelenting reliance on road transport.

Energy demand in road transport is projected to grow at an annual rate of 3.5 %. By fuel type, the trend of growth will show significant differences, with gasoline growing at 2.9 % per year, diesel at 4.2 % per year, and natural gas at 9.2 % per year. In the year 2000, the annual gasoline consumption per capita in Malaysia was 358 (Liters per Person), this number has increased 1.8% in three years only to become 364.9 in 2003.

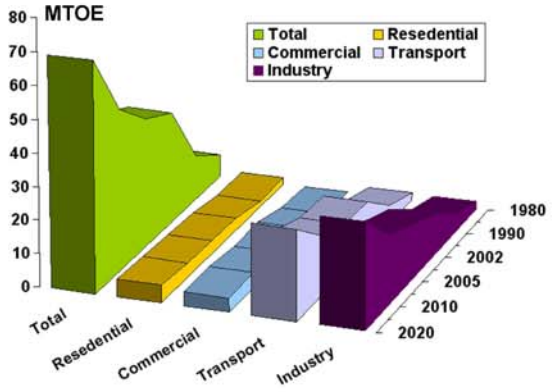

Fig 1. Malaysia final energy demand by sector (1980-2020)

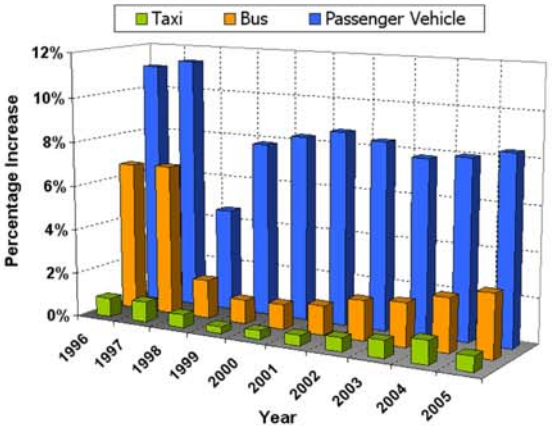

Fig 2. Annual growth of passenger vehicle ownership in Malaysia 1996-2005

TWHR as a Solution

The U.S DOE predicts that the price per Watt for thermoelectric vehicular waste heat recovery shall decrease exponentially with the emergence of QW technology reaching $ 0.1~0.3 U.S after the year 2010. QW (i.e. Quantum Well) technology utilizes raw materials which are 10 times cheaper than those used at the present moment.

The designs reported by the authors in provide energy density of 19.9 W/Kg and 19.51 W/kg respectively. These energy density values are enough to target an investment size of 800,000 thermoelectric generator units with a total cost of 900 Million MYR. The predicted saving in annual fuel consumption is around 800 Million MYR based on annual gasoline consumption and price of 372 Liters per capita in 2008 and 2.7 RM/Liter, respectively, and alternator fuel consumption of 6~7% of the total vehicle fuel consumption, as in figure 3.

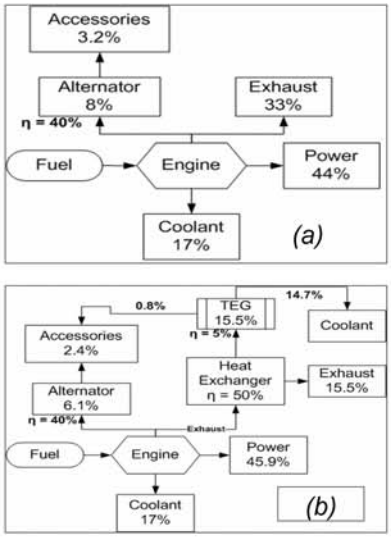

Figure 3. (a) Engine input/output power without TEG (b) Engine input/output power with 5% efficient TEG

The 1.9% increase in engine output power, which is indicated in figure 8-b, is due to the reduction in alternator power by the same percentage. This reduction is replaced by the power generated from the TEG based on 5% efficiency condition. However, the state of the art efficiency could reach to 8% which would lead to increase the engine efficiency by 3.1% reaching 47.1%.

A for future thermoelectric materials such a QW superlattice thin films, the investment cost shall decrease according to the decrease in raw materials cost reaching 0.1% of the cost required for the present day technology.

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