Solutions to Current Problems Arising from ICEV Use Environments

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Abstract

With a template consequential from $M|G|\infty$ queue system, we create a model where *ICEV*-**I**nternal **C**ombustion **E**ngine **V**ehicles, commonly cars but not only, get idle, in a rare conventional energy ambience, and are either recycled, turning either *EV*-**E**lectric **V**ehicles or *HEV*-**H**ybrid **E**lectric **V**ehicles or *FCEV*- **F**uel **C**ell **E**lectric **V**ehicles , or dismantled becoming *DV*-**D**ismantled **V**ehicles. The model permits concluding that when the rhythm *ICEV* become *EV*, *HEV*, *FCEV*, *DV* is greater than the rate at which they become idle the system has a tendency to balance. Moreover, it is performed a cost-benefit analysis.

Keywords: *ICEV, EV, HEV, FCEV, DV,* $M|G|\infty$*, hazard rate function.*

JEL Classification: C18

AMS Classification: 60G99

1 INTRODUCTION

Worldwide many of non-renewable resources seem to be over-exploited and conventional sources of energy such as oil, gas and coal will collapse, very likely, in a near future. Maybe firstly oil, then gas and lastly coal. New prospects for business become obvious and practiced all over the world related to new sources of energy.

The objective of this paper is to show that *ICEV*, which work based on oil, may have an economically viable alternative use when this conventional source of energy collapses; or they may become dismantled, giving also conditions so that this action is economically viable. Indeed, in the showing model, using infinite servers' queues -see for instance (Ferreira and Filipe, 2017) and (Filipe and Ferreira, 2019)- we state that too many *ICEV* will become idle if either conventional energy misses or conventional energy becomes replaced by a renewable one. We accept as true that *ICEV* dismantle or recycling will become very usual because there will not be a way to get them functional with conventional oil, since the moment it is depleted.

We shall state that it is essentially relevant the cadence at which we perform the recycling and dismantling actions, being important in this analysis the hazard rate function of the service time.

Note that the hazard rate function of the service time depends essentially on the technology and protocols used to recycle and dismantle *ICEV*. Therefore, your choice, among those available now is of crucial importance.

It is imperative to draw attention here to another problem related to the future of cars, in this case in a very short time. This is the decision of major producers, in a very short time, possibly after 2030, for ethical and environmental reasons to stop making diesel cars, and to manufacture only gasoline, electric, hybrid and fuel cell cars.

Suppose the whole car manufacturers join this idea. Depending on the time it will take for the shortage of conventional energy, the case that the urgency to dismantle or recycle *ICEV* is not so pressing because it has occurred a preliminary replacement of diesel cars with either electric or hybrid or fuel cell cars. From the economic point of view, it is difficult to predict what will happen because there are several variables to consider, for example:

-Diesel cars will lose value due to this "decreed" obsolescence. Alternatively, will their value increase due to their increasing rarity?

-What will be the *cost* of dismantling or converting the existing diesel car manufacturing plants?

-What happen with the diesel cars in the meantime as they get idle: **dismantling**, **recycling**? Moreover, at what *cost*?

-Decreasing the number of diesel cars maybe will lead to a reduction in oil consumption, delaying the appearance of traditional energy shortage situation.

This work is commited to a goal that we think of primary importance: to contribute to the sustainability of humankind standard of living, compatible with a properly preserved natural environment.Here are some more in this path: (Andrade and Ferreira, 2007, 2009, 2010), (Andrade et al., 2012), Ferreira(2014), (Ferreira and Matos, 2018), (Ferreira et al., 2008, 2012, 2014, 2014a, 2016), (Filipe et al., 2012), (Matos and Ferreira, 2005, 2006), (Matos et al., 2018) and (Selvarasu et al, 2009).

Some of this material is presented in (Ferreira and Filipe, 2019).

2 EVOLVING THE MODEL

In $M|G|\infty$ queue, customers arrive according to a Poisson process at rate λ, receive a service which length is a positive random variable with *distribution function* $G\ (\cdot)$ and mean value α. There are infinite servers, that is: when a customer arrives, it always finds an available server, see for instance (Ferreira and Filipe, 2017) and (Filipe and Ferreira, 2019). The service length of a customer is independent from the other customers' service length and from the arrivals process. An important parameter is the *traffic intensity,* called ρ=$\lambda\alpha$. $M|G|\infty$ queue has neither losses nor waiting.

Concerning the present study, the costumers are the *ICEV* that become idle. The arrivals rate is the rate at which the *ICEV* become idle. The service length for each one is the time that goes from the instant they get idle until the instant they are either recycled or dismantled.

Define for the service length, the *hazard rate function* as:

$$h(t) = \frac{g(t)}{1 - G(t)} \quad (1)$$

At expression (1), $g(t)$ is the *probability density function* associated to $G(t)$. The *hazard rate function* of the service length is the rate at which the services end. For the situation under study here, is the rate at which the motorcars are either recycled, turning either *EV* or *HEV* or *FCEV*, or dismantled, turning *DV*.

Note that the *hazard rate function* of the service length depends essentially on the technology and protocols used to recycle and dismantle *ICEV*. Therefore, your choice, among those available now is of crucial importance.

Denoting $p_{1'0}(t) = G(t)e^{-\lambda\int_0^t[1-G(v)]dv}$, the probability the $M|G|\infty$ queue has no costumers at instant *t*, being the time origin an instant at which a costumer arrives at the system finding it empty (symbol $1'$), see, for instance, Ferreira (1991)

Proposition1
If $G(t) < 1, t > 0$ continuous and differentiable and

$$h(t) \geq \lambda, t > 0 \qquad (2)$$

$p_{1'0}(t)$ is non- decreasing.

Dem.: It is enough to note that $\frac{d}{dt}\, p_{1'0}(t) = e^{-\lambda\int_0^t[1-G(v)]dv}\big(1 - G(t)\big)\big(h(t) - \lambda G(t)\big)$.
Obs.:
-If the rate at which the services end is greater or equal than the costumers 'arrivals rate $p_{1'0}(t)$ is non-decreasing.
-For the $M|M|\infty$ queue system, exponential service times, $h(t) = {}^1\!/_{\alpha}$ and equation (2) is equivalent to

$$\rho \leq 1 \ (3). \blacksquare$$

Either equation (2) evidences that if the recycling or the dismantling rate is greater or equal than the rate at which the motorcars become idle, the probability that the system is empty at instant *t*, meaning it that there is no idle *ICEV*, does not decrease with *t*. Therefore, the system tends to balance as far as time goes on.

3 ACHIEVING COST-BENEFIT ANALYSIS

In former section, we saw how important were the roles of *h (t)* and λ , in monitoring the *ICEV* recycling and dismantling management.

To perform an economic analysis, based on the model presented behind, consider additionally *p* as the probability, or percentage, of the *ICEV* arrivals designed to the recycling being consequently *1-p* the same to the dismantling. In addition, be *q* the percentage or probability of *ICEV* designed for recycling that turn *EV*; *r* will be the same for *ICEV* designed for recycling that turn *HEV*; and *1-q-r* will be the same for *ICEV* designed for recycling that turn *FCEV*. Call $h_i(t), c_i(t)$ and $b_i(t), i = EV, HEV, FCEV, DV$ the *hazard rate function*, the mean *cost* and the mean *benefit*, respectively for an *ICEV* turn either *EV* or *HEV* or *FCEV* or *DV*. Therefore, the total *cost* per unit of time for motor cars recycling and dismantling is:

$$C(t) = \lambda[pqc_{EV}(t) + prc_{HEV}(t) + p(1-q-r)c_{FCEV}(t) + (1-p)c_{DV}(t)] \ \ (4)$$

and the *benefit* per unit of time resulting from recycling and dismantling

$$B(t) = b_{EV}(t)h_{EV}(t) + b_{HEV}(t)h_{HEV}(t) + b_{FCEV}(t)h_{FCEV}(t) + b_{DV}(t)h_{DV}(t) \quad (5).$$

So, consider a period *T*. It must be $\int_0^T B(t)dt > \int_0^T C(t)dt$. It is not a simple matter to deal analytically with this expression. But, considering $b_{EV}(t), b_{HEV}(t), b_{FCEV}(t), b_{DV}(t)$ are all constant in $[0, T]$ with values $b_{EV}, b_{HEV}, b_{FCEV}, b_{DV}$, respectively. If moreover $G_{EV}(t), G_{HEV}(t), G_{FCEV}(t), G_{DV}(t)$ are all exponential, with means $\alpha_{EV}, \alpha_{HEV}, \alpha_{FCEV}, \alpha_{DV}$, respectively, and calling $C_i^T = \int_0^T c_i(t)dt, i = EV, HEV, FCEV, DV$:

- Recycling, turning *ICEV* in *EV*, is interesting, if

$$b_{EV} > \max\left\{\frac{\rho_{EV}[pqC_{EV}^T + prC_{HEV}^T + p(1-q-r)C_{FCEV}^T + (1-p)C_{DV}^T]}{T} - b_{HEV}\frac{\alpha_{EV}}{\alpha_{HEV}} - b_{FCEV}\frac{\alpha_{EV}}{\alpha_{FCEV}} - b_{DV}\frac{\alpha_{EV}}{\alpha_{DV}}, 0\right\} \quad (6)$$

with $\rho_{EV} = \lambda\alpha_{EV}$

- Recycling, turning *ICEV* in *HEV*, is interesting if

$$b_{HEV} > \max\left\{\frac{\rho_{HEV}[pqC_{EV}^T + prC_{HEV}^T + p(1-q-r)C_{FCEV}^T + (1-p)C_{DV}^T]}{T} - b_{EV}\frac{\alpha_{HEV}}{\alpha_{EV}} - b_{FCEV}\frac{\alpha_{HEV}}{\alpha_{FCEV}} - b_{DV}\frac{\alpha_{HEV}}{\alpha_{DV}}, 0\right\} \quad (7)$$

with $\rho_{HEV} = \lambda\alpha_{HEV}$

- Recycling, turning *ICEV* in *FCEV*, is interesting, if

$$b_{FCEV} > \max\left\{\frac{\rho_{FCEV}[pqC_{EV}^T + prC_{HEV}^T + p(1-q-r)C_{FCEV}^T + (1-p)C_{DV}^T]}{T} - b_{EV}\frac{\alpha_{FCEV}}{\alpha_{EV}} - b_{HEV}\frac{\alpha_{FCEV}}{\alpha_{HEV}} - b_{DV}\frac{\alpha_{FCEV}}{\alpha_{DV}}, 0\right\} \quad (8)$$

with $\rho_{FCEV} = \lambda\alpha_{FCEV}$

- Dismantling is interesting if

$$b_{DV} > \max\left\{\frac{\rho_{DV}[pqC_{EV}^T + p(1-q)C_{HEV}^T + p(1-q-r)C_{FCEV}^T + (1-p)C_{DV}^T]}{T} - b_{EV}\frac{\alpha_{DV}}{\alpha_{EV}} - b_{HEV}\frac{\alpha_{DV}}{\alpha_{HEV}} - b_{FCEV}\frac{\alpha_{DV}}{\alpha_{FCEV}}, 0\right\} \quad (9)$$

with $\rho_{DV} = \lambda\alpha_{DV}$.

This model is also be applicable to the dismantling and recycling situation resulting from the universal abandonment of the construction of diesel cars described in section 1. Now the option of recycling should consider a fourth option, the conversion of diesel cars to gasoline cars.

4 CONCLUSIONS

To apply this model, and get reliable conclusions, it is important to check customers' arrivals occur according to a Poisson process. For this kind of problem, this is pacific, in general, due to the huge quantity of motorcars, which owners certainly will look for these services. It is essential to estimate λ and *h(t)* to get conclusive results about the system after the available data. A correct estimate of λ will depend also on the arrivals process to be Poisson in real. Moreover, certainly the way is to decide for a mean λ estimate for a given period since it is easy to admit that the arrivals rate will depend on time. Also, it is correct to acknowledge that with very large populations, such as the ones dealt in these situations, the estimation of *h(t)* is in general technically complicated. Then the best is to directly estimate *h(t)* instead of estimating first the service time distribution followed by the consequent computation of *h(t)*. For exponential service times all this is particularly easy since in this case *h(t)* does not depend on *t*.

From *Cost-Benefit* analysis performed standing on this model, it is concluded that there are minimum *benefits* above which both dismantling and recycling are interesting. Moreover, the most interesting option is the one for which this minimum *benefit* is the least.

The model here presented contributes for a better understanding of this kind of problems. With eventual modifications, to study for example some other social economic and financial problems such as unemployment, healthcare, pensions' funds, investment projects or repair systems the model is also applicable.

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