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Strategies for utilizing alternative fuels by Iranian passenger cars

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ABSTRACT: The current paper is an attempt to find a sustainable fuel strategy for passenger cars in Iran. Currently, most of Iran's passenger cars consume gasoline, a non-renewable fossil fuel. This fuel has well-known environmental impacts, including various kinds of pollutions, as well as the threat of quick running out. These general negative characteristics of gasoline are amplified by the high consumption rate of Iran's transportation sector, (e.g. about three times more than that of UK). The objective of this paper is firstly selecting possible alternative fuels for Iran's transportation sector, and then proposing the percent of cars consuming these alternative fuels (along with gasoline). The best strategies are proposed based on environmental and economic considerations, and hence are more sustainable decisions comparing with the other strategies. The best strategies are found using partial order theory and Hasse diagram technique, which is a multi-criteria decision analysis (MCDA) tool.

Key words: *Alternative fuels, passenger car, sustainable development, emission, MCDA*

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INTRODUCTION

Since the publication of "Our common future" (WCED, 1987) and the introduction of sustainable development, transportation has been on the center of the attention in many sustainability studies (Hardi and Zdan, 1997; Moffat, *et al*., 2001, Rassafi and Vaziri, 2005; Vaziri and Rassafi, 2001; Vaziri and Rassafi, 2003). It is because of the substantial impacts of transportation on both the environment and society. The environmental impacts of transportation are mainly categorized as air pollution, and non-renewable resource depletion. Both of these environmental impacts of transportation are directly related to the fuels it uses. Vehicles' engines use carbon and hydrogen from fuel, and oxygen and nitrogen from air during a combustion process to create energy. The unwelcome output of such burning process is the emission of dangerous gases into the environment. Fig. 1 shows the schematics of the combustion of a petroleum fuel. The pollutants of such a process have different environmental impacts. Some of these pollutants, including carbon dioxide, nitrous oxide, and methane, are called "Greenhouse Gases" which their impacts are global (APEA, 1995). The other pollutants with more local impact include carbon monoxide, sulfur dioxide, particulates, lead, and NMHC (Non-Methane Hydrocarbons). Fig. 2 shows the annual average concentration of pollutants and environmental standards at a central region of Tehran during 1995-2000 (Asadollah-Fardi, 2004). This variety of pollutants raises concerns about the negative consequences of transportation fuel usage. Despite of the above-mentioned disutility, fossil fuels are widely used by most of the transportation vehicles. At present, 100 percent of the Iran's demand for transportation is met by derivatives of the fossil fuel, petroleum. Fig. 3 illustrates the consumption of different fuels by Iran's transportation sector in year 2000 (IFCOO, 2004). Furthermore, these fuels are categorized as non-renewable resources, and soon or late, they will be finished. These two facts increases worries about the future status of the world in terms of sustainability issues, and imply that any decision regarding this kind of fuel is crucial to the human's future. The paper is an attempt to propose a more sustainable fuel strategy for Iran which may be both economically and environmentally better than the others. This is achieved by performing a multi-criteria decision-making tool, Hasse Diagram Technique (HDT), to propose the comparatively more sustainable fuel strategy. HDT is a tool that using partial order theory makes a comparison among the alternatives. The rest of the paper is organized as follows: First, the method, partial order theory and HDT are explained, and the resources which may be used as alternatives of ordinary fossil fuels are introduced, and their economical and environmental characteristics are discussed. Then, the more sustainable strategy for passenger car fuels is proposed after utilizing HDT. Finally.

MATERIALS AND METHODS

In this section the method that is used for the study, and the information based on which the analysis is carried out are introduced. The research was made for Iran and the study year was 2005. However, the time and geographical scope of the study can be altered or be extended.

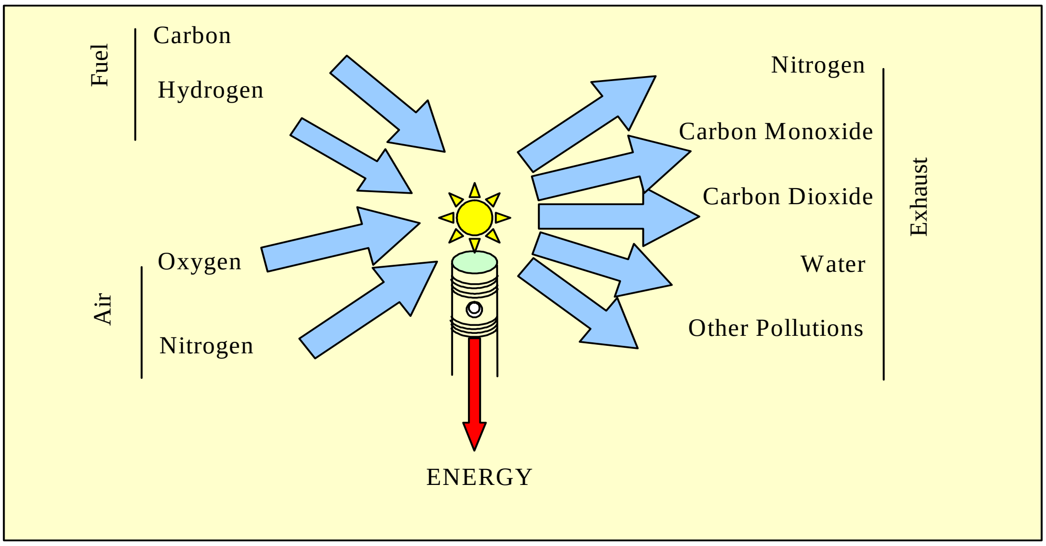

Fig. 1: Combustion of an average petroleum fuel (APEA, 1995)

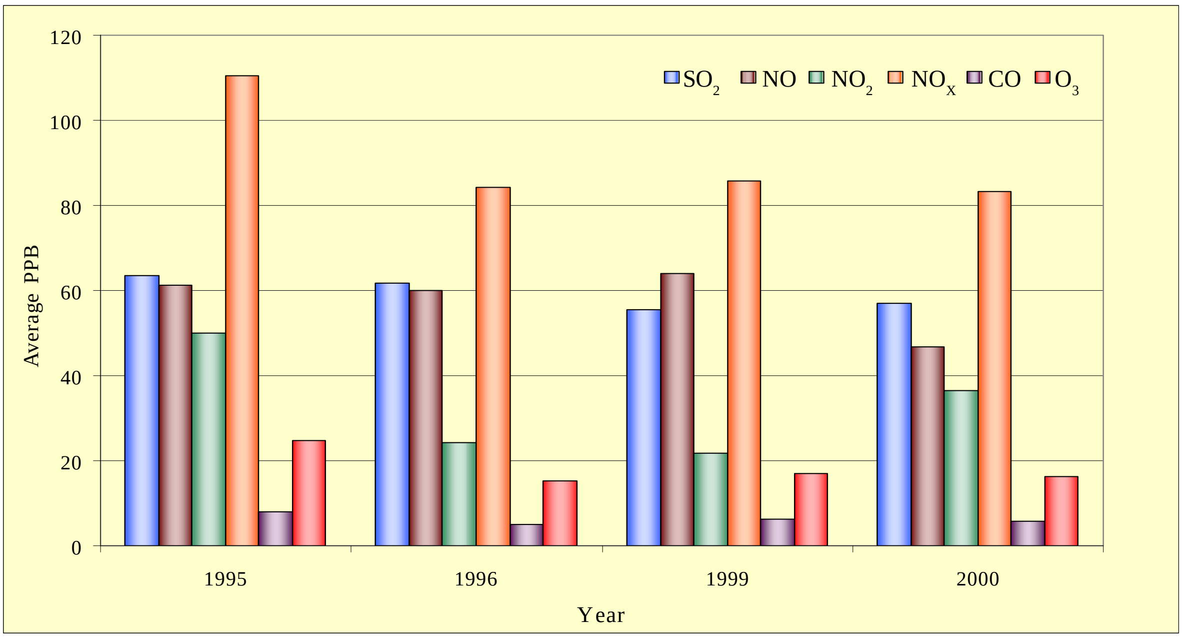

Fig. 2: Annual average concentration of pollutants at Tehran's center

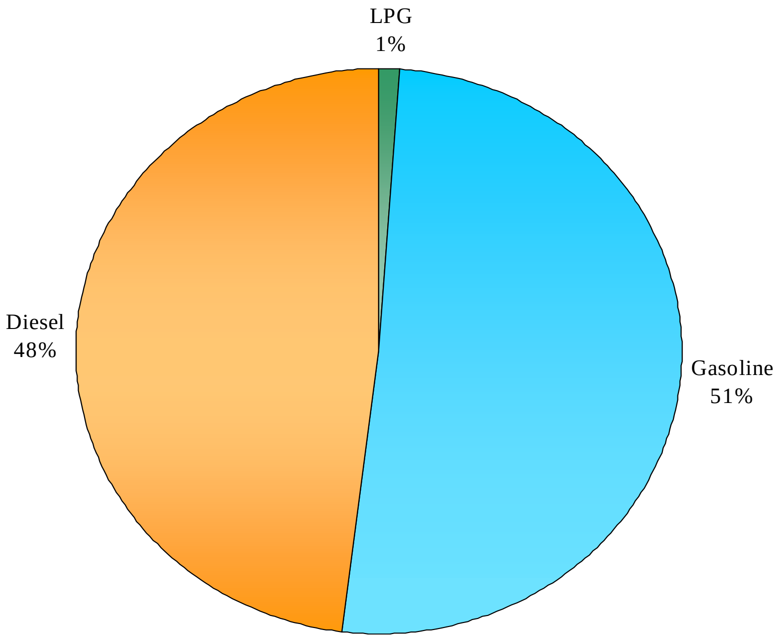

Fig. 3: Consumption of different fuels by Iran's transportation sector in year 2000 (IFCOO, 2004)

Partial order theory and hasse diagram technique

Partial order theory and Hasse diagrams appears to be a promising tool for decision-making particularly in environmental issues (Lerche and Sonersen, 2003). A partial order on a set P is a relation such as $\leq$ ($\subseteq P^2$) that is: *reflexive* ($x \leq x$), *antisymmetric* ($x \leq y$ and $y \leq x$ imply $x = y$), and *transitive* ($x \leq y$ and $y \leq z$ imply $x \leq z$). The set P is called the ground set of the pair (P, $\leq$) which is referred to as a partially ordered set or *poset*. The elements of a poset which can be alternatives or objects (or as in the current research, candidate fuels) are said to be partially ordered when it is impossible to find a mutual relation for all criteria. In a poset, different descriptors are used simultaneously as ranking parameters for a series of objects (i.e. fuels).

The ordered set can be visualized in a graph where each object is represented by a circle and the comparability of each pair of objects is shown by a link between those two objects.

The higher ranked of the two is given a point with higher vertical position. Due to the transitive characteristic of the posets, the graph can be greatly simplified by only drawing next neighbor connections. This kind of graphical representation of posets is referred to as a Hasse diagram (Lerche and Sonersen, 2003). In the next sections this technique is used to evaluate the candidate fuels. As an illustrative example for Hasse diagram, consider a group of four persons P={A, B, C, D} as a ground set, and this technique is used for comparative evaluation of their physical size. Suppose that the taller and heavier the persons are, the bigger they are. The heights of four persons of the test are 65", 71", 75", and 78", respectively. Their respective weights are 132 lb, 180 lb, 155 lb, and 200 lb. Therefore, the relation '>' is partial ordering on P and (P, >) is a poset. A Hasse diagram of such example is shown in Fig. 4. As it can be seen in Fig. 4, 'A' is both the shortest and the thinnest member among the others and thus takes the lowest place. On the contrary, 'D' is the biggest one because he is the tallest and heaviest. Therefore, his position is at the top of the diagram. However, the same reasoning for 'B' and 'C' is not as simple as that of 'A' and 'B'. 'B' is taller than 'C', while 'C' is heavier than 'B'. Thus, these people are not comparable with each other and take the same level in the diagram. The straight lines between each pair of people represent the existence of relation (i.e. >) between those two. For example if the height of 'B' is changed from 180 to 210 the Hasse diagram of such set would be changed as shown in Fig. 5. The missing line between 'D' and 'B' means that they are not comparable either. However, because 'D' is comparable with 'C' (and is located above it in the diagram), it is located in an upper level comparing with 'B' too.

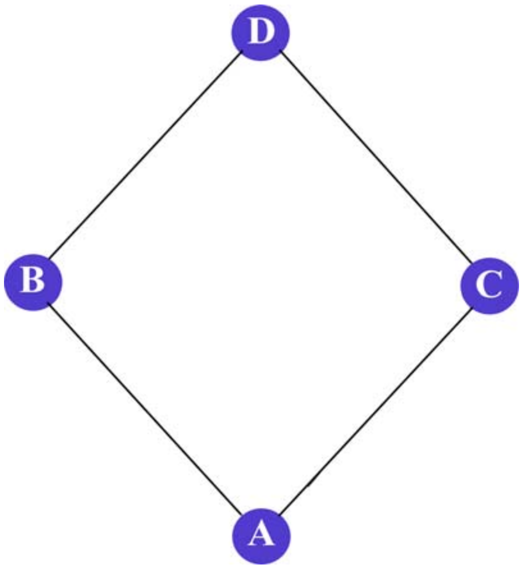

Fig. 4: Hasse diagram of the example

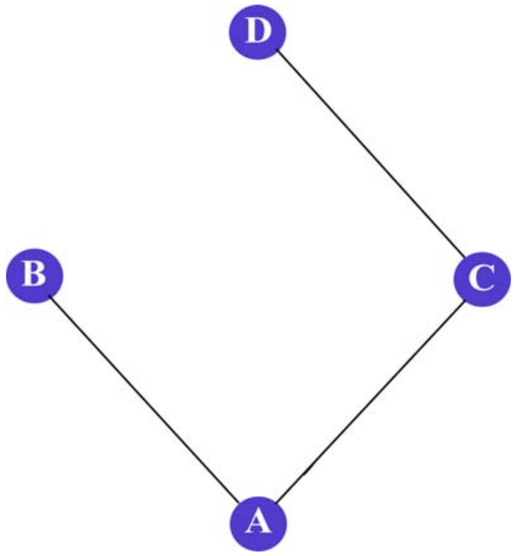

Fig. 5: New Hasse diagram of the example after applying the change

Candidate fuels and their characteristics

There are three major fuels currently in use by different modes of Iran's transport. Gasoline and diesel are the customary fuels consumed by vehicles, and LPG is the other source which is recently used only by a small portion of taxis (IFCOO, 2004). Diesel is used mainly by heavy duty vehicles and is not the paper's focus. The paper considers gasoline and its alternatives in the analysis of finding the more sustainable strategy for passenger car fuel. The term 'alternative fuel' no longer refers to experimental wishful thinking, but a range of commercially viable, safe materials which could feasibly replace gasoline and diesel. The most notable alternative fuels are LPG, CNG, hydrogen, and Electricity. Each of these fuels produces less greenhouse gas emissions comparing with gasoline. The selected alternatives of gasoline are LPG, which is currently being used by a limited number of vehicles, CNG, which is gradually being introduced to the community, and hydrogen, which is the current paper's choice as a renewable and environmentally sound fuel. The other alternative fuels such as methanol, ethanol, ethers, petrohol, etc, are impracticable due to economic limitations as well as the problem of their publicity. The listed fuels in Table 1 are possible resources that can be considered for further assessments. The codes represent candidate fuels and will be used in the appraisal. Therefore, the study focuses on the economic and environmental characteristics of the 4 candidate fuels (gasoline and its 3 alternatives) in order to find a more sustainable decision.

Economic aspects of fuels

The costs considered in this paper for each fuel include several items which are paid by both consumers and government. Consumers' costs include payment of the fuel price, and the cost of changing the vehicle engines (or extra payment in case of purchasing an alternative fuel car) in order to be able to use alternative fuels. Government's costs include subsidies given to the fuel prices, and the expenditures of constructing new stations for alternative fuels. It should be noted that in addition to the direct costs of fuels, a wide range of issues are involved in developing a successful alternative fuels program including publicity of alternative fuels, comparison with conventional fuels, etc. These factors will not be considered in the analysis because of their difficulties in measuring and quantification. Table 2 has listed the economic as well as physical characteristics of the study fuels.

Environmental aspects of fuels

As stated earlier, the environmental impacts of fuels are categorized in two major groups: pollution and non-renewable resource depletion. The first group contains the materials which are emitted to the environment after combustion process. They are greenhouse gases (CO_2, NOx, and CH_4), as well as CO, S, lead, particles, and NMHC. The weights of these emissions for each fuel have been listed in Table 3. The numbers in this table for each fuel reflect the polluting power of that fuel. The second group regards to the privilege of renewal of the fuel. In this paper a binary variable represents this characteristic (1: renewable, 0: non-renewable). This variable is also included in Table 3.

The total costs of each strategy

The main objective of the study is finding the more sustainable strategy for different car fuels. In other words, the study is looking for a mixed fleet of Iranian passenger cars consuming different fuels. ýTable 4 lists a set of strategies which can be applied for Iran's

Table 1: Candidate fuels for transportation sector

Fossil fuel		Non-fossil fuel	
Code	Fuel Name	Code	Fuel Name
FP	o Gasoline		
FL	o LPG	NH	o Hydrogen
FC	o CNG		

$$U_1^s = \sum_{i=1}^{4} IC_i \times N_i^s \qquad (1)$$

$$U_2^s = \sum_{i=1}^{4} R_i \times P_i \times N_i^s \qquad (2)$$

$$G_1^s = \sum_{i=1}^{4} SC_i \times S_i^s \qquad (3)$$

$$G_2^s = \sum_{i=1}^{4} R_i \times K_i \times N_i^s \qquad (4)$$

where U_1^s is total costs in each strategy 's' paid by users for either adapting their owned cars, or purchasing more expensive cars, which consume alternative fuels, IC_i is the amount of such cost for

Table 2: Economic and physical characteristic of fuels

i	Fuel	Energy consumption rate	Energy content	Density	Consumers' cost		Government's cost	
					Upgrading cost	Fuel price	Station Construction cost	Fuel Subsidy
	Code	R_i	EC_i	D_i	IC_i	P_i	SC_i	K_i
	Unit	liter/day/Car	GJ / lb	lb / liter	$ / car	$ / liter	$ / station	$ / liter
1	FP	10.75	0.020045	1.548	0	0.094	150,000	0.141
2	FL	10.32	0.020889	1.032	300	0.001	1,000,000	0.234
3	FC	9.59	0.022472	0.400	500	0.023	900,000	0.014
4	NH	3.35	0.064355	0.018	650	0.002	1,400,000	0.025

Table 3: Emissions of fuels and their possibility for renewal

i	Fuel	Pollutants							Renewal ability
		NOx	N_2O	CO_2	CH_4	CO	SO_2	NMHCg	
	Code	PR_i^1	PR_i^2	PR_i^3	PR_i^4	PR_i^5	PR_i^6	PR_i^7	
	Unit	Kg/GJ	Kg/GJ	Kg/GJ	Kg/GJ	Kg/GJ	Kg/GJ	Kg/GJ	
1	FP	0.861	0.0024	73.0	0.0342	6.8344	0.005	1.1558	0
2	FL	0.898	0.002	56.0	0.0192	1.61	0.000	0.3585	0
3	FC	0.898	0.002	56.9	0.0192	1.61	0.0003	0.3585	0
4	NH	0.053	0.000	0.0	0.0000	0.012	0.000	0.012	1

passenger car fleet. To find comparable measures for different strategies, the total economic costs of fuels and total environmental pollutions of the country should be computed. The Economic costs of fuels in each strategy (C^s) include those of users (U_j^s) and Government (G_j^s), are computed as follow:

each car that consumes fuel 'i', N_i^s is the number of cars that use fuel 'i' in strategy 's'. U_2^s is total costs in each strategy, s, paid by users for purchasing fuels, R_i is the rate of consumption of fuel 'i' by each car, P_i is the unit price of fuel 'i'. G_1^s is total government costs in each strategy, s, for constructing new fueling stations, SC_i is the cost of building a station for fuel 'i', S_i^s is the number of required stations for fuel 'i' in each strategy 's'. G_2^s is total government costs in each strategy, s, for subsidizing fuels, and K_i is the amount of subsidy for each unit of fuel 'i'. The environmental aspect of strategies in this study comprises total air pollutions emitting during a year. The different pollutions of fuels in each strategy are computed as follow:

$$PO_k^s = \sum_{i=1}^{4} EC_i \times D_i \times PR_i^k \times R_i \times N_i^s$$

k=1, 2, …, 7 (5)

where PO_k^s is the total emission of pollution of type 'k' in strategy 's', EC_i is the energy content of fuel 'i', D_i is the density of fuel 'i', PR_i^k is the polluting rate of type 'k' from fuel 'i'. Table 5 has listed the above parameters and variables and their units for a more convenient reference. The above equations are used for computations of total costs and pollutions of the country having the following assumptions:

- Strategies are static. It means they will not be applied gradually over several years, but all at once at the beginning of the year.
- The car to station ratio is constant for all fuels and equals about 1100 car/station (Iranian Fuel Consumption Optimization Organization, 2004).
- The subsidization for hydrogen (, which is currently an unused fuel in Iran) is assumed to be similar with that of other fuels.
- Number of available cars in the study year is about 2 *10^6 (ITRS, 1997).

Table 5: Proposed strategies to be evaluated

Strategy Code	Percent of cars that should consume:				Strategy Code	Percent of cars that should consume:			
	FP	FL	FC	NH		FP	FL	FC	NH
S1	30	0	40	30	S24	40	30	30	0
S2	30	0	50	20	S25	50	0	30	20
S3	30	0	60	10	S26	50	0	40	10
S4	30	0	70	0	S27	50	0	50	0
S5	30	10	30	30	S28	50	10	20	20
S6	30	10	40	20	S29	50	10	30	10
S7	30	10	50	10	S30	50	10	40	0
S8	30	10	60	0	S31	50	20	20	10
S9	30	20	30	20	S32	50	20	30	0
S10	30	20	40	10	S33	60	0	20	20
S11	30	20	50	0	S34	60	0	30	10
S12	30	30	30	10	S35	60	0	40	0
S13	30	30	40	0	S36	60	10	20	10
S14	40	0	30	30	S37	60	10	30	0
S15	40	0	40	20	S38	60	20	20	0
S16	40	0	50	10	S39	70	0	20	10
S17	40	0	60	0	S40	70	0	30	0
S18	40	10	30	20	S41	70	10	10	10
S19	40	10	40	10	S42	70	10	20	0
S20	40	10	50	0	S43	80	0	10	10
S21	40	20	20	20	S44	80	0	20	0
S22	40	20	30	10	S45	80	10	10	0
S23	40	20	40	0					

- Hydrogen-fuel cars use compressed hydrogen in very thick, heavy tanks. Such tanks can hold hydrogen at around 100 times atmospheric pressure, or 1500 PSI. The Ideal Gas Law identifies that in these conditions the hydrogen would only take up 29 cubic feet, which is equivalent to around 60 of those high pressure storage tanks (to match the effective capacity of the 15 gallon gasoline tank) (Johnson, 2004). The density of hydrogen in such state equals 0.018 lb/liter.
- The study was performed in 2005 in Iran.

RESULTS

Applying the previously-mentioned assumptions and equations will result in forming Table 6 which includes the total costs and pollutions of the country. It is worth noting that some of the columns have different unit base (per year and per day). Furthermore, there are two types of costs: U_1^s and G_1^s are capital costs that will be paid once for several years, while U_2^s and G_2^s are operating costs. This will not affect on the final results, because the variables (columns of this table,) will not be added together before introducing to the HDT. Furthermore, they will be rescaled into a 0-1 interval, in order to assign equal weightings to the different aspects of fuels. The next step (after rescaling the values) is finding environmental and economic indices of each strategy. These are found by the following equations:

$$E^s = \frac{\sum_{k=1}^{7} NORM(PO_k^s)}{7} \quad (6)$$

$$C^s = \frac{\sum_{i=1}^{2} NORM(U_i^s) + \sum_{i=1}^{2} NORM(G_i^s)}{4} \quad (7)$$

where (NORM) is the function that rescales the variables, E^s is the environmental index of strategy ‘s’, and C^s is the economic index of strategy ‘s’.
These indices have been tabulated in two last columns of Table 6. Fig. 6 is the Hasse diagram of the 45 selected strategies. Because all of the indices (i.e. costs and pollutions) are undesirable, the relation for the poset is ‘<’ and the lower strategies in this Fig. are better (i.e. more sustainable) than the others.

DISCUSSION AND CONCLUSION

The results confirm that 4 strategies at the lowest layer show better performance comparing with the others. They are S4, S3, S2 and S1.

Table 5: Description of variables and parameters

Code	Description	unit
U_1^s	Total users’ upgrading costs in strategy ‘s’	$ /year
U_2^s	Total users’ fuel costs in strategy ‘s’	$ /day
G_1^s	Total fueling stations construction costs in strategy ‘s’	$ /year
G_2^s	Total fuel subsidies in strategy ‘s’	$ /day
PO_k^s	Total emission of type-k pollution in strategy ‘s’	Kg /day
IC_i	Unit upgrading costs of type-i cars	$ /car
N_i^s	Number of type-i cars in strategy s	Cars
R_i	Unit consumption rate of type-i cars	Liters / day / car
P_i	Unit price of type-i fuel	$ / liter
SC_i	Unit cost of building a type-i station	$ / station
S_i^s	Required type-i stations in strategy ‘s’	Stations
K_i	Unit type-i fuel subsidy	$ / liter
EC_i	Energy content of type-i fuel	GJ / lb
D_i	Density of type-i fuel	Lb/liter
PR_i^k	Type-k polluting rate of type-i fuel	Kg / GJ

However, the strategies of the second layer also, show acceptable results. The number of comparable elements in the Fig. reveals that among the 4 strategies of the first layer and the 6 ones of the second layer, S4 and S3 are in better situation and 'second best' group include strategies S2, S1, S8, S7, S6, S5, S17 and S16.

Table 6: The total costs and pollutions of the country

S	U_1^s	U_2^s	G_1^s	G_2^s	PO_1^s	PO_2^s	PO_3^s	PO_4^s	PO_5^s	PO_6^s	PO_7^s	E^s	C^s
unit	M$/year	M$/day	G$/year	M$/day	ton/day	ton/day	Kt/day	ton/day	Kton/day	ton/day	ton/day		
S1	790.00	0.79	1.50	1.07	234.41	0.62	18.54	8.17	1.48	1.02	256.13	0.42	0.70
S2	760.00	0.83	1.41	1.08	249.85	0.65	19.52	8.50	1.51	1.03	262.30	0.43	0.69
S3	730.00	0.87	1.32	1.09	265.29	0.69	20.50	8.83	1.53	1.03	268.47	0.45	0.67
S4	700.00	0.92	1.23	1.10	280.73	0.72	21.48	9.16	1.56	1.04	274.64	0.47	0.65
S5	750.00	0.74	1.52	1.52	258.88	0.67	20.05	8.69	1.52	1.02	265.90	0.44	0.73
S6	720.00	0.79	1.43	1.53	274.32	0.71	21.03	9.02	1.55	1.02	272.07	0.46	0.71
S7	690.00	0.83	1.34	1.54	289.76	0.74	22.01	9.36	1.58	1.03	278.24	0.48	0.69
S8	660.00	0.87	1.25	1.55	305.20	0.78	22.99	9.69	1.61	1.03	284.41	0.49	0.67
S9	680.00	0.75	1.45	1.99	298.79	0.76	22.54	9.55	1.59	1.02	281.84	0.48	0.73
S10	650.00	0.79	1.35	2.00	314.23	0.80	23.52	9.88	1.62	1.02	288.01	0.50	0.71
S11	620.00	0.83	1.26	2.01	329.67	0.83	24.50	10.21	1.65	1.03	294.18	0.52	0.70
S12	610.00	0.75	1.37	2.46	338.70	0.85	25.03	10.40	1.67	1.02	297.78	0.53	0.74
S13	580.00	0.79	1.28	2.47	354.13	0.89	26.01	10.73	1.69	1.02	303.95	0.54	0.72
S14	690.00	0.94	1.36	1.34	276.39	0.74	22.43	10.12	1.91	1.35	327.08	0.52	0.69
S15	660.00	0.99	1.27	1.35	291.82	0.78	23.41	10.45	1.94	1.36	333.25	0.54	0.68
S16	630.00	1.03	1.18	1.36	307.26	0.81	24.39	10.78	1.96	1.36	339.42	0.55	0.66
S17	600.00	1.07	1.09	1.37	322.70	0.85	25.37	11.11	1.99	1.37	345.59	0.57	0.64
S18	620.00	0.95	1.29	1.81	316.29	0.83	24.92	10.98	1.98	1.35	343.02	0.56	0.70
S19	590.00	0.99	1.20	1.82	331.73	0.87	25.90	11.31	2.01	1.36	349.19	0.58	0.68
S20	560.00	1.03	1.11	1.83	347.17	0.90	26.88	11.64	2.03	1.36	355.36	0.59	0.67
S21	580.00	0.90	1.31	2.27	340.76	0.89	26.43	11.50	2.02	1.34	352.78	0.59	0.72
S22	550.00	0.95	1.22	2.28	356.20	0.92	27.41	11.83	2.05	1.35	358.96	0.60	0.71
S23	520.00	0.99	1.13	2.29	371.64	0.96	28.39	12.16	2.08	1.36	365.13	0.62	0.69
S24	480.00	0.95	1.15	2.74	396.11	1.01	29.90	12.68	2.12	1.35	374.89	0.64	0.71
S25	560.00	1.15	1.14	1.63	333.80	0.90	27.30	12.40	2.36	1.68	404.19	0.64	0.67
S26	530.00	1.19	1.05	1.64	349.24	0.94	28.28	12.73	2.39	1.69	410.37	0.65	0.65
S27	500.00	1.23	0.95	1.65	364.68	0.97	29.26	13.07	2.42	1.69	416.54	0.67	0.64
S28	520.00	1.10	1.15	2.09	358.27	0.96	28.81	12.93	2.41	1.68	413.96	0.66	0.69
S29	490.00	1.15	1.06	2.10	373.71	0.99	29.79	13.26	2.44	1.68	420.13	0.68	0.68
S30	460.00	1.19	0.97	2.11	389.15	1.03	30.77	13.59	2.46	1.69	426.30	0.70	0.66
S31	450.00	1.10	1.08	2.55	398.18	1.05	31.30	13.78	2.48	1.68	429.90	0.70	0.70
S32	420.00	1.15	0.99	2.56	413.61	1.08	32.28	14.11	2.51	1.68	436.07	0.72	0.68
S33	460.00	1.30	1.00	1.91	375.77	1.03	31.19	14.36	2.79	2.01	475.14	0.74	0.66
S34	430.00	1.35	0.91	1.92	391.21	1.06	32.17	14.69	2.82	2.02	481.31	0.76	0.65
S35	400.00	1.39	0.82	1.93	406.65	1.10	33.15	15.02	2.85	2.02	487.48	0.77	0.63
S36	390.00	1.30	0.93	2.37	415.68	1.12	33.68	15.21	2.86	2.01	491.08	0.78	0.67
S37	360.00	1.35	0.84	2.38	431.12	1.15	34.66	15.54	2.89	2.02	497.25	0.80	0.65
S38	320.00	1.30	0.85	2.84	455.59	1.21	36.17	16.06	2.94	2.01	507.02	0.82	0.67
S39	330.00	1.50	0.77	2.19	433.19	1.19	36.06	16.64	3.25	2.35	552.26	0.86	0.64
S40	300.00	1.55	0.68	2.20	448.63	1.22	37.04	16.97	3.28	2.35	558.43	0.87	0.62
S41	290.00	1.46	0.79	2.65	457.66	1.24	37.57	17.16	3.29	2.34	562.03	0.88	0.66
S42	260.00	1.50	0.70	2.66	473.09	1.28	38.55	17.49	3.32	2.35	568.20	0.90	0.64
S43	230.00	1.66	0.64	2.47	475.16	1.32	39.95	18.59	3.68	2.67	623.21	0.96	0.63
S44	200.00	1.71	0.55	2.48	490.60	1.35	40.93	18.92	3.70	2.68	629.38	0.98	0.61
S45	160.00	1.66	0.56	2.93	515.07	1.40	42.44	19.44	3.75	2.67	639.15	1.00	0.64

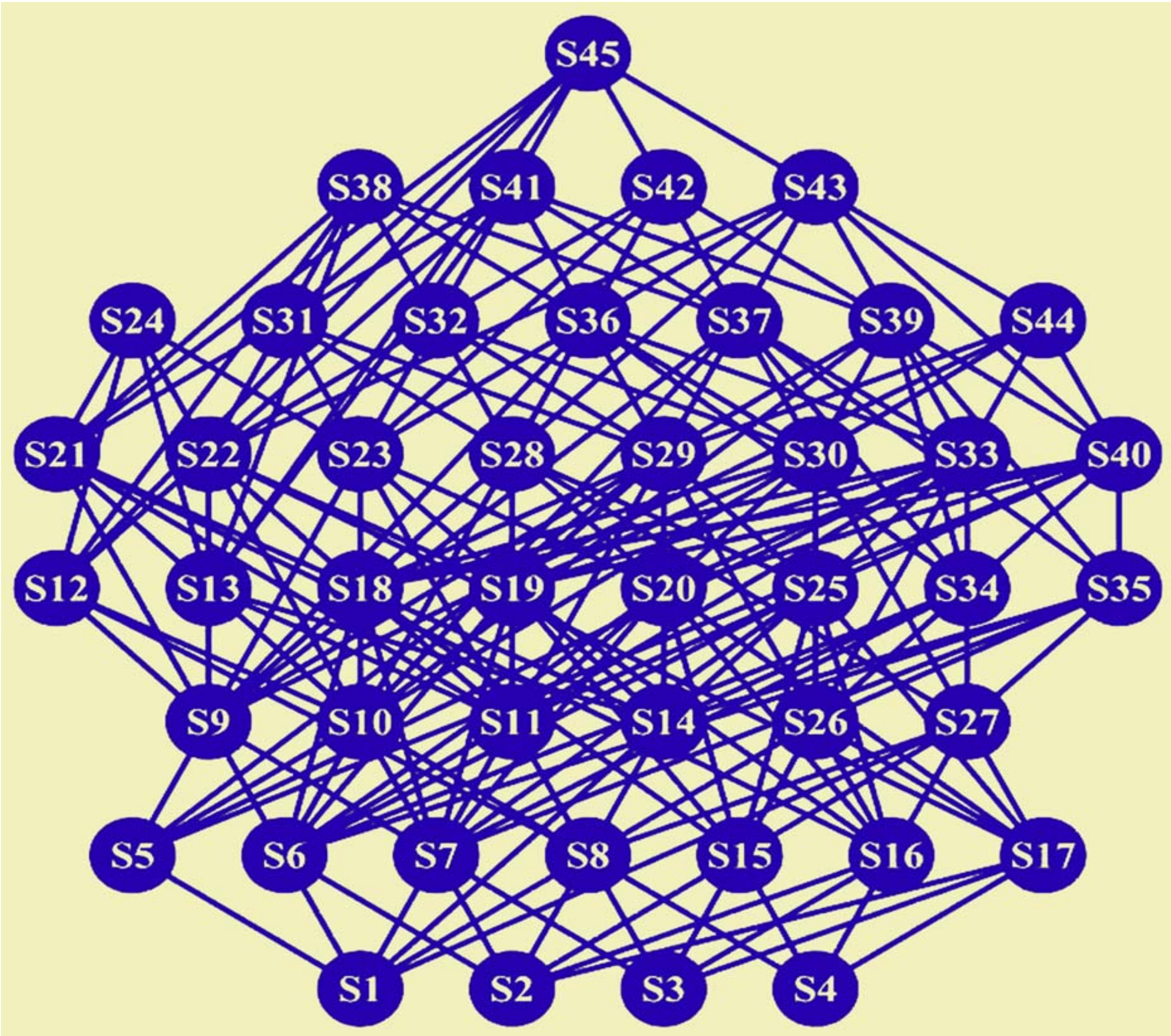

Fig. 6: Hasse diagram of selected strategies

On the other hand, amongst the first 10 better strategies, those with lower percentage of gasoline are far from current situation of fuel status in the country (and consequently more impractical). The result of ranking the 10 strategies with considering the pollution as the major criterion is S1, S2, S5, S3, S6, S4, S7, S8, S16 and S17 and if the economic factors are of the major importance, the result will be: S17, S4, S16, S3, S8, S2, S7, S1, S6, and S5. Finally as a conclusion, by considering both of the two mentioned factors (as assumed in the partial order theory logic) and also compatibility with the current situation of fuel status in Iran, the proposed strategies of this study are S16 and S3. To sum up, after selecting possible alternative fuels for Iran's transportation sector, and proposing the strategies (the percent of cars consuming alternative fuels along with gasoline), the best strategies were found using partial order theory and HDT. The Hasse diagram of the 45 selected strategies revealed that 10 strategies showed better results than the others. They were S4, S3, S2, S1, S8, S7, S6, S5, S17 and S16. The number of comparable elements in the Fig. and compatibility with the current situation of fuel consumption status in Iran reveals that among the 10 strategies, S16 and S3 are the most sustainable decisions. Thus the proposed strategies of this study are utilizing 40% (or 30%), 50% (or 60%), and 10% for gasoline, CNG, and hydrogen respectively.

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