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# ALTERNATIVE ELECTRICITY PRODUCTION TECHNOLOGIES FOR TURKEY: IS THERE A DIFFERENCE BETWEEN THE STUDENTS' AND ACADEMICS' PERCEPTIONS ON THEIR MERITS?

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## ABSTRACT
*We study the electricity supply problem of Turkey from the perspectives of academics and students by taking into account three main electricity production technology alternatives which are nuclear, coal and hydro technologies. We tackle the problem as a group decision making procedure and use Analytic Hierarchy Process (AHP) to reach both individual and group decisions. Our aim is to identify the similarities and differences among the perceptions of students and academics on these technologies. We evaluate all individual, subgroup and group decisions and compare the results in terms of the weights and ranks of technology alternatives and criteria that are used in the study. All group results are in favor of hydroelectricity production technology. Nuclear energy technology is the least preferred alternative in both students group and overall group decisions. The academics group does not make a significant distinction between nuclear and coal technologies.*
**Keywords:** Energy policy planning, Group decision making, AHP

## 1. INTRODUCTION
Electricity supply problem is a multi-criteria energy decision problem having several conflicting objectives. There exist many conventional and renewable energy technology alternatives each with different technological, economic, social and environmental consequences. Renewable energy resources [1] are regularly replenished. However they need high technology to be utilized although resources are cheap and free. Solar, wind, hydroelectric plants are some of the renewable energy resources. Non-renewable energy sources are coal, oil, natural gas and nuclear power. Fossil fuels which are coal, oil, natural gas are major contributor to global warming and acid rains. Nuclear energy is one of the cleanest energy sources in the world. However there are some disadvantages such as; storing nuclear waste and radioactive risks for human health and environment.
In this study, we consider the electricity supply problem of Turkey from the perspectives of academics and students by taking into account three main electricity production technology alternatives which are nuclear, coal and hydro technologies. Our aim is to identify the similarities and differences among the perceptions of students and academics on these technologies.
We tackle the problem as a group decision making procedure involving many decision makers and use Analytic Hierarchy Process (AHP) to reach both individual and group decisions. AHP is practically and widely used in many areas such as social, economic, industrial, ecological and energy systems problems [2,3,4]. AHP is a decision analysis procedure calculating importance of alternatives by making pairwise comparisons [5]. The alternative having the higher score is the best alternative. The main idea of AHP is a weighted average of the ratings of the alternatives. A criteria hierarchy tree

is developed to clarify the representation and facilitate the decision maker. This makes it possible to concentrate on pairwise comparison of two criteria of the same level and belonging to the same parent one at a time.

## 2. ELECTRICITY PRODUCTION TECHNOLOGY SELECTION PROBLEM

We model the electricity supply problem of Turkey using AHP. Part of the AHP model is given in Figure 1 where the top three hierarchies are presented. The first hierarchy is the overall objective, the second and third ones are the main and sub criteria respectively, and finally the fourth levels which are not given in Figure 1 are the decision alternatives. We consider three decision alternatives within the model which are hydroelectric power plants, nuclear power plants and coal burning power plants.

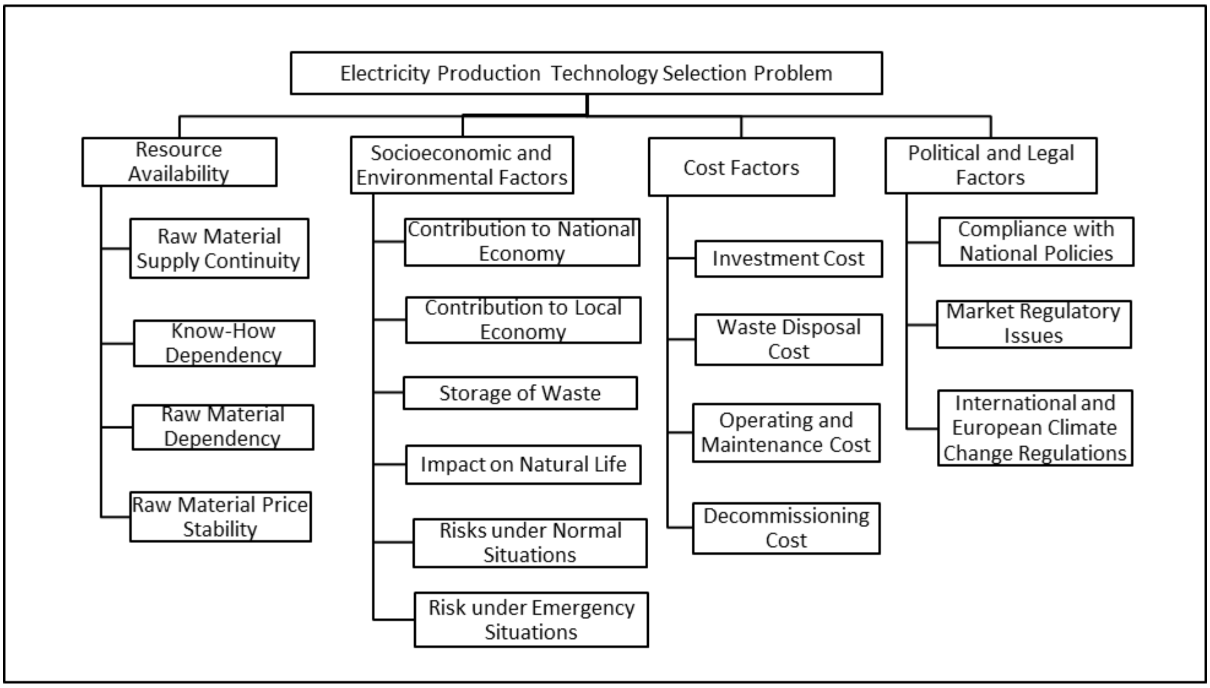


*Figure 1. Criteria hierarchy of the AHP model*

Main and sub criteria are inspired from [6] with some differences reflecting the recent conditions in Turkey. Resource availability is defined as some characteristic of the raw material which is used as fuel in energy power plant selected. Decision alternatives are evaluated in terms of raw material supply continuity since changes in demand occur by raw material supply discontinuity. Technology or raw material used in power plants can depend to abroad. So know-how and raw material dependencies are the other important criteria. Finally raw material price stability is important for electricity price stability.

Socioeconomic and environmental factors have two perspectives. Socioeconomic perspective consists of the contributions of power plants to national and local economy. Environmental perspective considers storage of waste, impact on natural life, risks under normal and emergency situation.

Power plant costs play an important role on determining the electricity price. Four types of costs are handled as sub criteria in the model. These are costs related with investment, waste disposal, operating and maintenance, and decommissioning.

Political and legal regulations involve governmental or international policies and regulations for building or operating power plants. Compliance with national policies consists of future plans of the government related with building and operating of power plants. The other two sub criteria consider the regulations of the market and international and climate change.

## 3. RESULTS

Our aim is to identify the similarities and differences among the perceptions of students and academics on different energy production technologies. We employ AHP with four representative academics and four students in Energy Systems Engineering Department in Bahçeşehir University.

*Table 1. Results of the AHP model*

| | Group Decisions | | | Individual Decisions | | | | | | | | Range Information | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Decision alternatives*** | **Overall** | **Students** | **Instructors** | **Student 1** | **Student 2** | **Student 3** | **Student 4** | **Instructor ME** | **Instructor CE** | **Instructor EE** | **Instructor IE** | **Students** | **Instructors** |
| Hydroelectric | 0.403 | 0.429 | 0.362 | 0.513 | 0.390 | 0.325 | 0.514 | 0.136 | 0.603 | 0.401 | 0.598 | 0.189 | 0.467 |
| Nuclear | 0.239 | 0.181 | 0.325 | 0.146 | 0.182 | 0.192 | 0.175 | 0.523 | 0.146 | 0.348 | 0.167 | 0.046 | 0.377 |
| Coal | 0.357 | 0.390 | 0.314 | 0.341 | 0.429 | 0.483 | 0.311 | 0.341 | 0.252 | 0.251 | 0.234 | 0.173 | 0.107 |
| ***Main Criteria*** | | | | | | | | | | | | | |
| Resource Avialibility | 0.461 | 0.482 | 0.434 | 0.532 | 0.389 | 0.508 | 0.463 | 0.560 | 0.658 | 0.109 | 0.419 | 0.145 | 0.549 |
| Socioeconomic & Environmental | 0.168 | 0.138 | 0.204 | 0.083 | 0.179 | 0.216 | 0.103 | 0.159 | 0.165 | 0.208 | 0.171 | 0.133 | 0.049 |
| Cost Factors | 0.237 | 0.254 | 0.217 | 0.257 | 0.304 | 0.193 | 0.263 | 0.236 | 0.113 | 0.158 | 0.260 | 0.111 | 0.147 |
| Political & Legal Factors | 0.136 | 0.127 | 0.145 | 0.128 | 0.129 | 0.083 | 0.171 | 0.045 | 0.063 | 0.525 | 0.150 | 0.089 | 0.481 |
| ***Resource Availability*** | | | | | | | | | | | | | |
| Raw Material Supply Continuity | 0.160 | 0.249 | 0.084 | 0.274 | 0.186 | 0.228 | 0.243 | 0.088 | 0.045 | 0.033 | 0.101 | 0.087 | 0.069 |
| Know-How Dependency | 0.109 | 0.058 | 0.168 | 0.049 | 0.038 | 0.042 | 0.117 | 0.103 | 0.256 | 0.059 | 0.136 | 0.079 | 0.197 |
| Raw Material Dependency | 0.120 | 0.086 | 0.135 | 0.070 | 0.082 | 0.119 | 0.067 | 0.345 | 0.256 | 0.012 | 0.080 | 0.052 | 0.332 |
| Raw Material Price Stability | 0.071 | 0.089 | 0.046 | 0.140 | 0.082 | 0.119 | 0.036 | 0.024 | 0.101 | 0.005 | 0.101 | 0.104 | 0.096 |
| ***Socioeconomic & Environmental*** | | | | | | | | | | | | | |
| Contribution to National Economy | 0.027 | 0.013 | 0.048 | 0.007 | 0.011 | 0.022 | 0.011 | 0.019 | 0.028 | 0.074 | 0.033 | 0.014 | 0.055 |
| Contribution to Local Economy | 0.022 | 0.015 | 0.029 | 0.007 | 0.020 | 0.020 | 0.011 | 0.015 | 0.009 | 0.074 | 0.017 | 0.012 | 0.065 |
| Storage of Waste | 0.018 | 0.012 | 0.023 | 0.004 | 0.040 | 0.014 | 0.005 | 0.033 | 0.009 | 0.024 | 0.011 | 0.036 | 0.023 |
| Impact on Natural Life | 0.023 | 0.010 | 0.043 | 0.004 | 0.041 | 0.009 | 0.005 | 0.038 | 0.028 | 0.021 | 0.038 | 0.037 | 0.018 |
| Risk Under Normal Situations | 0.021 | 0.030 | 0.014 | 0.015 | 0.037 | 0.040 | 0.023 | 0.013 | 0.009 | 0.010 | 0.008 | 0.025 | 0.005 |
| Risk Under Emergency Situations | 0.057 | 0.058 | 0.048 | 0.046 | 0.031 | 0.111 | 0.049 | 0.042 | 0.083 | 0.006 | 0.064 | 0.081 | 0.077 |
| ***Cost Factors*** | | | | | | | | | | | | | |
| Investment Cost | 0.114 | 0.124 | 0.095 | 0.138 | 0.130 | 0.094 | 0.107 | 0.120 | 0.046 | 0.042 | 0.099 | 0.045 | 0.078 |
| Waste Disposal Cost | 0.044 | 0.068 | 0.026 | 0.065 | 0.113 | 0.028 | 0.083 | 0.023 | 0.015 | 0.009 | 0.038 | 0.086 | 0.029 |
| Operating & Maintenance Cost | 0.053 | 0.036 | 0.072 | 0.038 | 0.020 | 0.058 | 0.032 | 0.081 | 0.046 | 0.019 | 0.107 | 0.037 | 0.088 |
| Decommissioning Cost | 0.026 | 0.025 | 0.024 | 0.016 | 0.041 | 0.014 | 0.041 | 0.012 | 0.005 | 0.088 | 0.016 | 0.027 | 0.083 |
| ***Political & Legal Factors*** | | | | | | | | | | | | | |
| Compliance with National Economy | 0.053 | 0.050 | 0.055 | 0.064 | 0.015 | 0.045 | 0.094 | 0.010 | 0.027 | 0.137 | 0.061 | 0.079 | 0.126 |
| Market Regulatory Issues | 0.031 | 0.034 | 0.029 | 0.032 | 0.052 | 0.014 | 0.036 | 0.003 | 0.009 | 0.332 | 0.017 | 0.039 | 0.329 |
| European & Inter. Climate Reg. | 0.051 | 0.042 | 0.061 | 0.032 | 0.062 | 0.025 | 0.041 | 0.031 | 0.027 | 0.056 | 0.072 | 0.037 | 0.045 |

Since Energy Systems Engineering is an interdisciplinary subject, the academics consulted in the study have been chosen to possess different educational backgrounds such as mechanical (ME), chemical (CE), electrical (EE) and industrial (IE) engineering and different field experiences. On the other hand, the students involved in the study are selected from among the honor senior students studying at the same department of the same university.
We evaluate all individual and group decisions and compare them with each other. Group decisions are achieved by using the geometric mean of each pairwise comparison of individuals in the group [7]. Each student or instructor makes his/her own decision individually in pairwise comparison using a scale of 1-9 with the help of an expert who is experienced in applying AHP. The results are presented in Table 1 in terms of the weights of decision alternatives and criteria that are used in the study where results of group decisions are given in columns 2-4, individual evaluations of students and instructors are given in columns 5-8 and 9-12 respectively. Columns 13 and 14 give the range information of students group and instructors group respectively.
All group results are in favor of hydroelectricity production technology. Nuclear energy technology is the least preferred alternative in both students group and overall group decisions. Furthermore this is valid in all students' individual decisions. The academics group does not make a significant distinction between nuclear and coal technologies. But this is not true for individual evaluations of instructors. Almost all instructors evaluate the hydroelectricity alternative as the best one except the instructor with mechanical engineering background.
In rating the main criteria, all groups have similar ratings. They rate the resource availability first with a significant distinction from the other main criteria. However when we look at the individual decisions, again all students rate the resource availability first whereas this is not true for the instructors The instructor with electrical engineering background evaluate the political and legal factors as the most important criterion whereas to his opinion, resource availability is the least important one. Range information of the instructors supports this observation.
As for the sub criteria, students' and instructors' ratings differ significantly. For instance instructors group evaluates the know-how dependency as the most important criterion whereas for the students group raw material supply continuity is the most important one with a very large rating. Also in their judgment, know-how dependency criterion comes the sixth.

## 4. CONCLUSION

We develop an AHP model for the electricity production technology selection problem of Turkey and evaluate the group and individual decisions of students and instructors of Energy Systems Engineering Department of Bahçeşehir University. Results show that students are more similar in their decisions whereas instructors have significant differences in their ratings. These differences may be because of their different educational background or different field experiences. But in order to make stronger conclusions, more students and instructors should be included in the study.

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