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Ethanol Fuel Use - Promising Prospects for the Future

by Michael Jackson, Stanford University, USA and Maria M. Morales, SEI

In the past few years, the prospects for ethanol fuel use have grown around the world. Once confined to a few specialized countries, ethanol production and consumption have begun to spread to all corners of the globe.

Photo: Anders Arvidson

Common public transportation in Zambia

Brazil, the pioneer of the modern ethanol fuel industry in the 1970s, still remains both the dominant producer and consumer of ethanol fuels, though in recent years, the industry has grown dramatically in the United States, Europe, Africa, and Asia. In 2002, the global ethanol consumption reached 38.3 billion litres and is projected to exceed 41.3 billion litres by 2005.[1] This volume is still tremendously small (1%) in terms of transport fuels however, as worldwide oil consumption in 2002 exceeded 4,000 billion litres.[2]

Countries inspired by a desire to reduce greenhouse gas emissions in order to meet their Kyoto Protocol targets, have turned to ethanol fuels as a cheap and proven alternative to reduce vehicular emissions. Political instability in the Middle East has further motivated countries to develop their own fuel supply to ensure the security of supply and promote internal economic growth. Persistent lobbying from agricultural groups has also encouraged governments to pursue aggressive energy policies to create crop price stability and reduce the need for government subsidies on exported surpluses.

Ethanol policies

There have been a number of different policy strategies undertaken by governments wishing to develop a domestic ethanol fuels programme. Ethanol fuels are most commonly introduced into the fuel market through blends with gasoline. Many countries have mandated blends of a certain percentage in domestic gasoline supplies. In Brazil, with the most highly developed ethanol fuel programme, gasoline supplies contain up to 25% ethanol. In 2003, both India and China unveiled regional pilot programmes with the eventual goal of introducing 10% blends throughout their domestic gasoline supplies. While these policies don't necessarily mandate the use of ethanol, ethanol and its substituent ethyl-tertiary-butyl ether (ETBE) are the most viable replacements for methyl-tertiary-butyl-ether, (MTBE), an octane enhancer

[1] Gobi International. *Ethanol – The International Market 2002*. London, UK: 2002.

[2] AP Energy Business Publications. "World Oil Supply More Diverse with non-OPEC Production Increasing." July 2003.

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Photo: Maria M. Morales

Sugarcane field in Nfolosi, Kwazulu, Natal, South Africa

in gasoline. Seventeen states in the United States have banned or severely limited the use MTBE and the federal government is currently considering a nationwide ban, in the hopes of introducing renewable fuels to the country's transport sector. Thus a ban on MTBE gives ethanol almost complete control over the oxygenate market. Other countries have pursued a renewable fuels standard (RFS) that specifies a volume of ethanol to be used in transportation fuels at some point in the future. The United States Congress is currently debating a RFS that would increase domestic ethanol use from 9.5 billion litres in 2002 to 19 billion by 2012. In 2001, the European Union established goals for the percentage of member states' fuels to be bio-based by 2020, aiming for 20% biofuels by that time.

Still other countries have pursued tax breaks and subsidies for ethanol fuel production and use. In 2001, the European Union issued a directive to allow member states to adjust their excise tax structures in order to favour the use of biofuels. In 2002, India revised its Sugar Development Fund Act to allow the government to give concessionary loans to sugar mills trying to upgrade their ethanol production capabilities. Subsidies are in place to reduce the cost of ethanol fuels to consumers in the United States, Australia, and many others.

Photo: Maria M. Morales

A mountain of cane stalks. Gledhow Sugar Mill, South Africa

Ethanol technologies and trade

The future of ethanol fuels appears to be bright, as countries around the world have begun to pursue aggressive ethanol strategies in recent years. One of the issues surrounding the future of ethanol comes from the prospect of international trade in ethanol. While one of the major justifications for ethanol fuels seems to be a desire to maintain a secure domestic supply, importation of ethanol could provide the fuel to many countries at a greatly reduced cost and ensure against poor crop yields in any one country. However, most countries have high importation tariffs on ethanol to make imported fuel uncompetitive with the domestic supply. In the United States, there is a 54 cents per gallon tariff that protects ethanol suppliers in the Midwest states from cheaper ethanol supplies that could be imported from Brazil or elsewhere in South America.[3]

One of the beauties of loosening these trade restrictions on ethanol is that this will allow developed countries, who are unable to produce ethanol as cheaply as many equatorial developing countries to obtain the fuels at a reduced cost, while providing for economic development to countries that desperately seek it. Furthermore, the spread of ethanol trade allows the transfer of technologies from experienced ethanol producers to fledgling programs in other countries. For example, a Brazilian ethanol company announced in 2002 that it would install an ethanol refinery in Portugal to help, "back the EU's policy of promoting clean fuels."[4]

[3] MacDonald, Tom. California Energy Commission. Email interview, August 14, 2003.

[4] "Ethanol Ideas Exported From Brazil." *Renewable Energy Report*, Issue 52, June 2003.

Note to readers:

We regret that some of the addresses were mixed up at the distribution of RED Vol. 16 No. 3 due to a printing failure. If you haven't received this issue, please let us know, and we will include a copy in the next mailing.

The Stockholm Environment Institute (SEI) is an international research institute focusing on sustainable development. The Institute works through an international network of centres, associates, and field staff around the world.

The Climate and Energy Resources Programme is concerned with improving access to environmentally friendly energy services, promoting renewable energy and energy efficiency, and advancing global cooperation on climate change.

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Photo: Maria M. Morales

Ethanol blending depot, near Salima, Malawi. Ethanol has been blended with petrol nationwide in Malawi since 1982

Developments in ethanol fuel technologies are also likely to reduce costs and make ethanol an increasingly attractive option to consumers and goverments. In 2003, Volkswagen released its first flex-fuel vehicle, capable of running on fuel with any blend of ethanol and gasoline. Research into production of ethanol from cellulose-based feedstocks could allow producers to extract ethanol from corn stalks, sugarcane leaves, and other forms of organic waste. These technologies are likely to reduce feedstock costs, which could make ethanol fuels considerably more affordable, epecially in developed countries. Dedini SA, a Brazilian ethanol-engineering firm, announced in June 2003 that it had developed such technologies to extract ethanol from sugarcane leaves in addition to cane juice. It estimates that this technology could double the amount of ethanol produced per hectare of sugarcane.[5]

Benefits to be gained

Another reason ethanol fuels are so attractive, is that they represent an environment-friendly technology that is available today. While ethanol-fuelled automobiles are probably not likely to be the permanent solution to environmental concerns in automotive fuels, in the very least, they provide a temporary solution while research into fuel cells and other advanced technologies are under development. By investing in such practical technologies today, governments around the world enjoy significant environmental progress as well as domestic economic development, and realize two goals that often appear at odds with one another.

As countries around the world begin to take note of the benefits provided by ethanol fuels and develop their own programmes, it is important to consider what the future might hold for ethanol fuels and how emerging technologies and policies can help guide this development in a desirable direction.

There are still many issues to be addressed in considering the future of ethanol fuels. Many critics have charged that the energy balance of ethanol fuels is flawed, arguing that the energy inputs exceed the energy content of the final product. However, a study released by the United States Department of Agriculture in July of 2002 refutes these claims and finds that ethanol has an output:input energy ratio of 1.34:1.[6] Furthermore, another study found that the energy balance of gasoline is actually negative, giving ethanol a 1.42:1 output energy ratio compared to gasoline.[7]

Perhaps even more important than the energy balance from an environmentalist perspective is the amount of carbon released in the production of the fuel as compared to its final energy content. If agricultural processes and transportation of ethanol release large enough quantities of carbon dioxide, running a vehicle on ethanol could potentially result in higher carbon emissions than a clean diesel or gasoline engine. Thus, some have argued that ethanol fuels should be evaluated based on their carbon dioxide balance, indicative of the production process. For example, due to the photosynthetic efficiency advantage of sugarcane over corn and a large ethanol transportation infrastructure already established, ethanol in Brazil has a much lower carbon dioxide emissions:final energy ratio than ethanol produced in the United States. At present, there is no distinction made between the two types of ethanol fuels, despite the fact that the Brazilian ethanol reduces considerably more carbon dioxide emissions. Recognition of this dissimilarity is essential to making ethanol fuels sustainable and maximizing the environmental benefits of its use.[8]

Conflicting needs

In addition to considering the carbon dioxide released during ethanol production, it is important to consider the effects of drastically increasing agricultural production in order to meet an increased demand for the fuel. Increased agriculture necessitates more land use change, more pesticides, and more fertilizer, all of which bring a host of different environmental concerns. Scientists debate the extent to which agricultural capacity can be expanded to meet a global demand for ethanol, especially as the rapidly growing population in the develop-

[5] Knight, Patrick. "New Flex-Fuel Engines Transform Consumer Options in Brazil" *F.O. Lichts: World Ethanol and Biofuels Report*, July 23, 2003.

[6] Shapouri, Hosein, James Duffield, and Michael Wang. "The Energy Balance of Corn Ethanol: An Update." United States Department of Agriculture, July 2002.

[7] Alternative Fuels Data Center. *Alternative Fuels Comparison Chart.* May, 2003.

[8] Lindqvist, Rodolfo. Marketing Director, Salixsphere. Personal interview, August 18, 2003.

ing world struggles to feed itself. While all of these externalities can be addressed to yield an ethanol fuel that is better for the environment than our conventional fossil fuel-based consumption, it is important to consider them and not blindly accept the environmental benefits of ethanol fuels just because they are cleaner at the tailpipe.

According to many analysts, the major obstacle to ethanol fuels becoming more widespread is simply a question of cost. However, there is great potential that these costs can be considerably reduced as more widespread ethanol use generates increased attention towards the science and economics behind ethanol fuels. As ethanol production is presently dependent on agricultural feedstocks, which comprise anywhere from 30-60% of the total cost of production, minimizing feedstock costs are central to making ethanol fuels more affordable to consumers.

Photo: Pressens Bild

Ethanol car, Sweden

Much of this focus has been devoted to converting the entire feedstock plant into useful end products, allowing ethanol costs to decrease as manufacturing becomes more profitable. In southern Africa, whose primary ethanol feedstock is sugarcane, there have been efforts to restrict the practice of burning sugarcane residues in the fields after harvesting. Instead these residues, as well as sugarcane bagasse (a fibrous waste-product of sugarcane extraction), can be used for electricity cogeneration, allowing the plant to cover its own energy needs and even export electricity to the surrounding communities.[9] Many alcohol plants in Brazil already sell excess electricity to local utilities. Maintaining the capacity to convert these waste products into electricity or ethanol could also give alcohol producers additional stability by insulating them from price volatility in either the ethanol or electricity markets.

In addition to converting these feedstock waste products into electricity, research into production of ethanol from cellulose-based feedstocks (woody materials, stalks, and leaves) could allow these agricultural residues to be converted into more ethanol. Additional research into ethanol extraction from cellulose feedstocks promises to reduce ethanol costs by running production on the relatively cheap waste products of the agriculture and timber industries. Additionally, the use of cellulose-based feedstocks appeases concerns that a reliance on ethanol fuels could divert food from the rapidly growing world population. By providing farmers with a secondary flow of revenue, the technology could instead make food more affordable to the world's poor.

Ethanol and carbon trading

The emergence of carbon trading programs in response to many countries' ratification of the Kyoto Protocol will also enhance the affordability of ethanol fuels in comparison to gasoline and diesel. Because ethanol fuels offer a substantial reduction in carbon dioxide emissions, users can obtain carbon credits that can be sold to heavy polluters, again reducing ethanol costs while increasing that of fossil fuels. The European Union recently developed a carbon-trading programme that will take effect in 2005, while Japan has conducted several scenario simulations, with hopes to initiate its own nationwide trading system by as early as 2005. As Russia considers ratification of the Kyoto Protocol, which would bring the agree-ment into effect, it seems likely that similar carbon trading schemes will continue to emerge around the world.

A combination of well-reasoned government policies and technological advancements in ethanol fuels could guide a smooth transition away from fossil fuels in the transportation sector. As environmental externalities continue to be incorporated into policy consideration and the fledgling industry emerges, ethanol fuels are likely to become and increasing attractive fuel alternative in the foreseeable future.

Acknowlegements

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[9] Johnson, Francis. "Sugarcane Resources in Southern Africa." *Tiempo: Global Warming and the Third World*. March 2000.

Delivery Mechanisms for Modern Energy in Rural Areas

by Monica Gullberg, Elisabeth Ilskog, Ångpanneföreningen (ÅF), Sweden; Anders Arvidson, SEI

What energy services contribute to facilitating rural development? What delivery mechanisms can provide these services? What is the institutional framework needed to make these delivery modes function? These were some of the topics that were discussed in a two- day workshop held in Bagamoyo, Tanzania in October 2003 organ- ised by SEI, ÅF and AFREPREN, focusing on Eastern and Southern Africa.

Many countries in Southern and Eastern Africa are undergoing a re-organisation of their respective energy sectors as a part of energy sector reforms. In this process, the responsibility for rural electrification is often shifted from national electricity utilities to rural electrification agencies that have recently been formed or are in the process of being formed. The thinking and debating about how these new organisations best can assist in facilitating rural development is ongoing and strategies are under development. For example, what tools and criteria are to be used in prioritising between different public investments in rural electrification and how should the financial support be channelled? Should a public agency provide technical and other support to private investors? Which delivery mechanisms for providing rural areas with electricity services are working in the region and what are the conditions that make them work and contribute to rural development?

Part of the answers lies in exchanging experiences being made in the different countries in Eastern and Southern Africa who in many ways share similar conditions. A workshop on "Delivery Mechanisms for Rural Electrification" that was arranged by SEI, ÅF and AFREPREN in Bagamoyo, Tanzania 28-29 October provided such a forum to exchange experience across countries in Eastern and Southern Africa.

The workshop was attended by 28 participants from Kenya, Mozambique, South Africa, Sweden, Tanzania, Uganda, Zambia and Zimbabwe representing energy service providers (private, public and co-operative), consumer groups, energy ministries, researchers, consultants, NGOs and Sida.

Photo: Anders Arvidson

Two engaged participants at the Bagamoyo workshop, Tanzania

Main questions

How can different types of delivery mechanisms referring to a combination of the energy supply technology and the organisation managing it - support rural development? And how can the expansion of different delivery mechanisms be supported and made to work efficiently? These were the main discussion topics during the workshop. Working in smaller groups, the participants discussed issues such as prioritisation between different energy services and their importance for rural development. The necessary incentives to expand the market for rural energy services and to what extent there is a national responsibility to supply rural households, farmers, workshops and other businesses with electricity were also discussed.

Case studies

Four different case studies were presented to provide an introduction to the topic and concrete examples of different types of rural electricity services delivery mechanisms and to inspire the participants in the following discussions. These were:

Experience from Tanzania's first electricity cooperative UECCO, by Mr Chambala, Urambo Electric Consumers Cooperative.

A Case study of the ESCO in Lundazi in Zambia, by Mr. Mukule Banda, Managing Director, Lundazi Energy Service Company, Zambia.

A Case Study on Community Micro Hydropower Project in Tungu-Kabiri, Kenya, by Mr. Daniel Theuri, Intermediate Technology Development Group (ITDG).

Rural electrification initiatives in Uganda: Kabale Project, by Mr. Tobias Karekaho, Norplan Uganda Limited.

Focus group discussions

Focus group discussions were used to explore the participants perception and experience of: (i) what rural development is, (ii) what role energy plays in rural development, (iii) which energy services are important for rural development, (iv) which delivery mechanisms are used and appropriate for dif-

ferent situations of energy service delivery in rural areas and (v) what the institutional framework requirements are for delivering different types of energy services and supporting different types of delivery mechanisms.

During the second day, three groups were formed and each narrowed down on one of the topics: (i) rural energy service demand, (ii) delivery mechanisms and (iii) institutional frameworks supporting rural energy service access and delivery mechanisms.

Social welfare

In the second day thematic session on rural energy service demand, it was fortified that income-generating activities are vital for rural development and that modern energy services supporting these activities are important. On the other hand, the group concluded that social welfare is imperative for sustainable economic development.

Industrial production, domestic lighting, cooking and heating, drinking water, and information and communication technologies where given high ranking in terms of areas where modern energy supply would facilitate rural development. Following on these were preservation of agricultural crops and irrigation.

Income opportunities

Income generating activities, and the respective energy delivery mechanisms supporting these activities, became the main focus in the group discussing delivery mechanisms. Energy services where categorised into three types, two "light electrical" and one "high load electrical".

Two different light electrical groups were motivated by the need to recognise the many service oriented, and handicraft based economic activities. One type of light electrical energy service needs is coupled to better household standards, especially for household lighting and communication technologies. For example, it was considered unfair to refer to lighting as a social welfare need only, since many small-scale businesses can flourish thanks to access to lighting – in houses and on market places. The other

Photo: Anders Arvidson

Group photo from the October workshop

light electrical, income generating activity refers to value-adding businesses using light electrical appliances for sewing, mending, boring, etc. The distinction is made because effective delivery mechanisms are assumed to be different. While service oriented and handicraft based businesses have shown to develop spontaneously in many villages, the value adding businesses seems to require more of training and support.

Therefore, the prioritised energy services were considered to be those supporting:

- Income generating activities through service-oriented businesses,
- Value-adding income generating activities,
- Small-scale industrial production.

Besides energy for income generating activities, the main areas of concern as seen in the participants' perspective, are social welfare and cooking. In the case of cooking LPG was brought forward as a solution.

Among the delivery mechanisms that can efficiently meet energy needs for income generating activities, PV systems, conventional stand alone systems and grid extension, where elaborated. In the workshop participants' view, all organisational forms (private companies, co-operatives, associations etc.) as equally suitable and functional as long as they take interest in rural development. Local organisations (private or other) for system management are important but will need support, most probably from decentralised government institutions, or NGO's. For all the delivery mechanisms discussed it is crucial that credits in appropriate sizes are available.

Supporting delivery mechanisms

A range of stakeholders have different roles to play in supporting a rapid expansion of modern energy services to rural areas including government, national utilities, private sector, donors, consumers, NGOs, community based organisations, line ministries, training institutions and academic institutions. Supporting rural development with access to modern energy services is not one mans job. Neither are modern energy services sufficient for the development of income generating activities. Conditions such as a market for products being manufactured with modern energy services needs to be accessible and an appropriately skilled workforce needs to exist or be trained. In the discussion on institutional frameworks to support delivery mechanisms, integrated planning

was stressed as something that could improve and speed up both accesses to rural electrification as well as improve the productive uses of electricity by coordinating government initiatives in the agricultural, health and education sector with initiatives in the energy sector. More transparency and public participation in defining government priorities strategies and budget allocations for example to subsidies for rural electrification was also called for.

Important messages

Important messages from the workshop include:

- Modern energy supply for income generating activities is important for rural development.
- A main challenge is to support income-generating uses of modern energy.
- Important factors in support include: other infrastructure (transport, market places), training (vocational and financial), and access to tools, including spare-parts.
- Modern energy solutions are as well important for social welfare, part of which is domestic uses.
- It is highly un-likely that the private market alone will deliver these energy services.
- In one way or the other, the Government needs to contribute money for rural development, including modern energy supply.
- Local organisations (private or other) for system management are important but will need support from decentralised government institutions or other suitable facilitators.
- Grid extension is not always the most appropriate solution for rural electrification from a macro-perspective point of view.
- Markets for e.g. household PV systems need to develop service responsibilities, or appropriate training for end users.
- The government should clearly make use of all the actors that have a role to play in extending electricity access. For this, clear rules and conditions based on a thoroughly communicated national strategy are needed.

A workshop report will be available for downloading at the SEI website (www.sei.se) during the spring of 2004.

This workshop was the second in a series of five international workshops to be organised by the Stockholm Environment Institute under the "Information and dissemination on energy and environment in developing countries", funded by the Swedish Development Cooperation Agency (Sida). ■

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"Ecotechnology and Sustainable Development" Education in Sweden

Mid-Sweden University offers a Master's Program in Ecotechnology and Sustainable Development at the Östersund campus. It has a strong focus on environment and aims to build and strengthen the competence needed for a holistic approach towards sustainable development, integrating societal, technological, and economical aspects of natural resources.The study program is nine months long (two semesters) in courses starting in September and ending in May. After successful completion of all course work, students are assigned a thesis project, which they elaborate on for a subsequent period of five months.

The program is open to students from all over the world, and courses are in English.

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Readers Survey – An Overview of the Professional Interests of the Typical Reader of Renewable Energy for Development (RED)

by Helena Forslund, SEI

In total, 217 persons responded to the questionnaire sent to RED newsletter readers. The following is a brief overview describing the most relevant results compared to a previous survey in 1999. The survey aims to guide the future direction of the newsletter and thus to satisfy the interests of our readers. We would like to direct our sincere appreciation to those readers that responded to the questionnaire.

The typical reader of RED

More than half of the respondents are engaged in energy-related consultancy and research. Yet another fairly large group of respondents are professionals within NGOs or in government administration. A quick comparison from the survey results published in 1999 indicates an increasing number of readers with a professional background in both consultancy and research during the past years. The survey undertaken in 1999 was to evaluate the content and format of the newsletter. At that time focus was around how RED was being used by the readers.

This time emphasis was on the particular interests of the reader. It was indicated that the respondents are mainly interested in information regarding for example innovative concepts and project-based experiences in both design and implementation. This was to some extent verified by the survey in 1999 assessing relevance of the newsletters to the respondents' work. In the recent survey, half of the respondents rank project design as most relevant and 24% as fairly relevant to their work, 73% of the respondents considered project implementation to be at least fairly relevant, as shown in Figure 1.

What are they interested in?

The findings from the survey show that the majority of the respondents are interested in rural energy, particularly end-use appliances in traditional energy systems, and small-scale electricity supply in modern energy systems. This result also reflects the fact that approximately half of the RED readers come from developing countries.

In contrast, few respondents were interested in urban (and peri-urban) energy. However, cross-cutting issues attracted about 40% of the respondents' serious attention. In this area, about half of the respondents find environmental issues the most interesting, as shown in Figure 2. Furthermore 25% of the respondents indicated policy and technology development as areas of greatest interests to them.

Once again we wish to direct our sincere thanks to those readers who took part in this survey. To us this provides important information of what focus the RED should have to best serve today's reader. ■

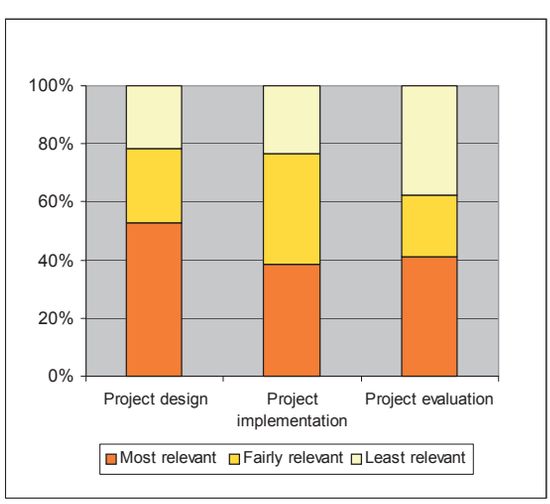

Figure 1 Relevance of various stages in energy projects

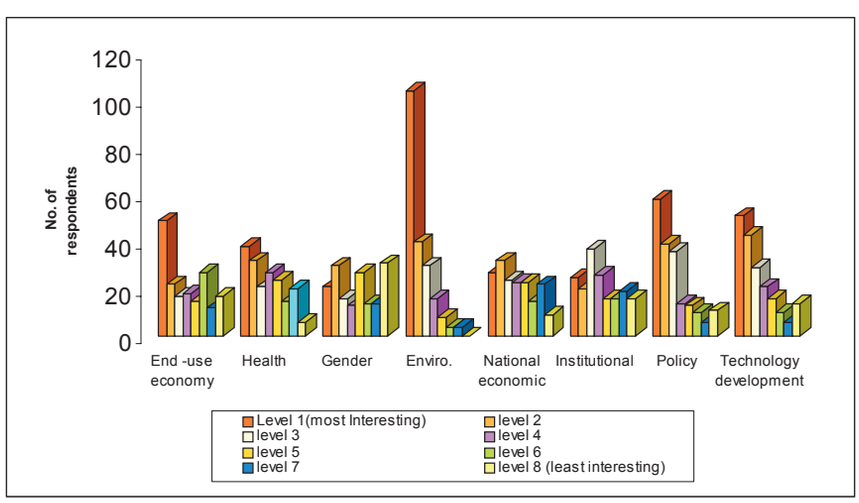

Figure 2 Relative interest in various cross-cutting issues