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UNDERUSED BIOMASS RESOURCES FROM FORESTS, AGRICULTURE AND OTHER SOURCES AS STRATEGY TO SECURE FEEDSTOCK SUPPLY FOR PRODUCTION OF BTL FUEL AND CELLULOSIC ETHANOL IN BRAZIL

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Abstract

Biomass-to-Liquids fuel and Cellulosic Ethanol are often referred to as “the second generation of biofuels”, presenting as major advantage over sugarcane-based or corn-based ethanol and seed-based biodiesel the fact that their production techniques do not interfere with the food chain. On the other hand an obstacle still to be overcome is how to secure feedstock supply in an amount that enables commercially viable production. The purpose of this paper is to assess how Brazil could take advantage of its large territory and plentiful natural resources, among other sources, to become one of the world-leading countries in the production of second-generation biomass-based biofuels.

1. Introduction

With 8,514,877 Km2 Brazil has the world’s 5th largest territory, after Russia, Canada, the United States and China. At first, one could have the impression that the larger one country’s territory is, more potential for biomass production it has. Nevertheless this can be a misleading assumption, since biomass production, either via agriculture or via forests, requires certain environmental conditions. Russia and Canada, for example, face very severe winter seasons in large portions of their territories, which makes things more difficult. Likewise the deserts in the United States represent soil that is barely able to produce any biomass. In fact, we could only draw a more accurate relation between arable land and biomass potential, which would show Brazil in a very good position. Despite serious environmental problems such as deforestation, the country owns a large area of forests and arable land. This represents a very strong advantage in the biofuels area because it addresses a critical point in the biofuels business case, which is security of supply. Considering that the final consumer market for biofuels is blossoming worldwide, in many counties supported by legislation requirements, that can be considered a solved part of the equation, while raw material supply still plays a bottleneck role and consequently worries investors, slowing the growth of biofuels in the market.

2. Second-generation Biofuels

The expression “second generation of biofuels” mentioned in this paper was created as a consequence of technology developments that enabled biofuel production in a radically new way: it would eliminate any interference to the food production chain – a major disadvantage of the “first generation of biofuels” (specially sugarcane-based or corn-based ethanol and seed-based biodiesel). Even though Brazil benefits from a great area of arable land, one cannot accept that the great growth of the (1st generation) biofuels production overshadows local poverty and undernourishment. Indeed two vital commitments that a developing country like Brazil needs to undertake is to (i)

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ensure that economic growth comes with wealth distribution, and (ii) be ready to meet the rising demand of the consumers' need (which includes not only energy but also food), as consequence of their enhanced income. Additionally other drawbacks of the "first generation of biofuels" are the employment of intensive agriculture technique, responsible for soil exhaustion and erosion, and the fact that many fertilizers and pesticides used in the activity have in their composition materials derived from oil, which directly collides with the "independency from oil" motto of the biofuels.

Another significant advantage of the next-generation biofuels is related to productivity. Considering that their production uses the whole plant (or animal), which is gasified or converted enzymatically, as indicated below, the result is that the same land area (or animal matter) is able to produce more energy if biomass is processed into second-generation biofuels, rather than regular biodiesel or bioethanol (that uses basically the oil extracted from seeds and animal fat or sugar, respectively).

Since they've already been mentioned many times in this essay, let's take a brief look at some of the second-generation biofuels, specially BtL and cellulosic ethanol. BtL is the contracted form of "Biomass-to-Liquids", a liquid fuel obtained through a process that can also use as feedstock natural gas and coal, which generate respectively "GtL" and "CtL" fuels. These three acronyms – which are also referred as a group as the "XtL family", "X" representing the kind of employed feedstock – designate indeed the same final product, which is obtained through Fischer-Tropsch synthesis after the raw material undegoes a gasification process (when necessary, which is the case of biomass and coal but not natural gas) and can be used in the engines of the diesel cycle with no modifications producing much less pollutant emissions. One of the world's leading companies in the BtL research field is the german Choren Industries. Cellulosic ethanol is the ethanol made from plant fiber, i.e. cellulose. Different processes can be employed to produce it. Two of them are either via enzymatic hydrolysis, using an enzyme called "cellulase", or via synthesis gas fermentation, in which biomass undergoes the stages of gasification, fermentation and distillation. While the former has been developed for a couple of years by companies like Iogen Corporation, the latter is used by BRI Energy. The Brazilian corporation Dedini is also developing its own process to obtain cellulosic ethanol, which they call "Dedini Rapid Hydrolysis".

Despite not being mentioned in the title, Bio-oil and Biogas are also worth mentioning because they can use as feedstock biomass matter that cannot be transformed into first-generation biofuels. Bio-oil is a dark liquid obtained when biomass is employed in a thermochemical process called "fast pyrolysis", which could be briefly described as heating biomass with limited to virtually no oxygen in the reaction zone. The yields of produced liquid product vs. weight of starting dry biomass could reach up to a 75% ratio. This fuel can substitute fuel oil or diesel in applications like boilers, engines and turbines, being able to generate mainly heat or electricity. It can also serve as feedstock for the chemicals and materials industry. Companies like DynaMotive, Ensyn and the Brazilian Bioware are currently pursuing the implementation of commercial-scale bio-oil plants. At last biogas is the production of methane via fermentation under anaerobic conditions of organic matter such as manure, sewage and other kinds of organic solid waste. The gas obtained in biogas digesters can have characteristics very similar to natural gas, if sufficiently purified from the gaseous by-product of the reaction: carbon dioxide. There is already a biogas-fueled train that connects the Swedish cities of Linkoping and Vastervik. A company called Svensk Biogas AB provides the fuel and biomass employed in the process is basically fat and entrails from locally raised cattle.

3. Feedstock Supply

Although the production of the aforementioned biofuels is based on relatively new technologies – we're witnessing today the implementation of the world's first units of commercial scale in some cases – this is not the major hurdle we must overcome to achieve mass participation of second-generation biofuels in the fuels market. Neither is the market niche for them, since legislation all around the world guarantees a steadily growing market for biofuels. As mentioned above, the limitation in the biofuels equation consists in feedstock supply. This is even a greater concern for the production of second-generation biofuels because the underlying principle is "no interference to the food chain" and it could be a difficult task to obtain significant amounts of biomass without causing "side effects" to agriculture destined for food. Difficult yes, but not impossible, as we'll see. Three different areas that can effectively supply biomass that is currently underused will be assessed below. They are (i) Forests; (ii) Agriculture and (iii) Other Sources.

Before we proceed with the identification of the sources, it is important to briefly define biomass itself. Biomass is a very broad term used to describe material of biological origin "recently" generated (which means non-fossil matter, in contrast with crude oil for example that takes several million years to be formed). As such, biomass is constantly produced on Earth by the interaction of air, water, sunlight and soil. To clearly visualize the biomass cycle we could imagine an untouched forest. When a seed is dropped on the soil and grows into a tree we're watching biomass production. When the leaves of this tree fall and eventually when it dies microorganisms will break the produced biomass into its elementary constituent parts: water, carbon (in the form of CO2) and energy (in the form of

heat). That's why many experts consider biomass a form of stored solar energy, since the energy received from the sun is converted through the process of photosynthesis. The action of the microorganisms that leads to dissipation of energy in the environment is also cited as a strong reason to use biomass for human energy needs: if we don't use, then nobody will – which represents an undesirable waste. Now that we're roughly aware of the concept, what is biomass in our daily lives and our environment? Trees, crops, algae and other plants, as well as agricultural and forest residues for sure are examples of biomass and so are other materials like discarded pieces of slaughtered animals, animal manure, sewage, organic by-products of industrial processes and the organic fraction of our own household waste. In face of this diversity, some types of biomass are more suitable than others to be employed in the production of BtL, cellulosic ethanol, bio-oil and biogas.

3.1. Forests

Forests are a vital component of our environment and deserve to be treated and protected accordingly. The first rule about dealing with them must always be preservation, not only for us but specially for the generations to come. Nevertheless forests are clearly a major reserve of biomass-derived energy and can be treated as a renewable or non-renewable source, depending on its utilization manner. An aggressive approach to use forests without replacement, i.e. deforestation, would make them as non-renewable as an oil field (and would naturally magnify climate change issues). The reasonable way to integrate forests in the bioenergy industry is to replace the used matter. In some cases of very rare and/or fragile forest ecosystems not even this type of human intervention is tolerable – and in such cases our responsibility is to keep them away from the energy industry. Despite these cases, there are forest products that could play a significant role in the bioenergy field without causing harm to the nature. The most promising contribution could come from the pulp and paper industry, which is very strong in Brazil. Conglomerates like Suzano, Votorantin and Klabin, among others, produced in 2005 8.6 million tons of paper (world's 11th largest production) and 10.1 million tons of pulp[1] (7th in the world rank). This industry only uses the central part of the tree for their operations, while tops, leaves, branches and sawing residues remain unused. Considering the production numbers shown, it is possible to imagine the great amount of available biomass – virtually all of it obtained in strict compliance with the best practices regarding nature protection established by the Forest Stewardship Council[2], which were adopted by many Brazilian companies. This could represent a very important contribution to the fuels market because the paper industry would be able to supply raw feedstock on a regular basis. There's also another by-product regularly generated by the paper industry that can be gasified and transformed into a second-generation biofuel. It is called black liquor and it consists in biomass presented in liquid state. The Swedish company Chemrec AB is specialized in the development of black liquor gasification techniques.

The high degree of professionalism in the Brazilian pulp and paper industry as well as in the domestic scientific society certainly didn't let these valuable by-products pass by unnoticed. It was proposed to use them to generate electricity for the paper companies and even to sell to local power distribution companies the amount produced in excess of their needs. This initiative is definitely important and justifiable, given that: (i) energy prices are high in the country (following international markets), (ii) Brazil needs to expand its generation capacity, but the roll-out of new plants is happening slower than expected, mainly due to regulatory uncertainties (on 2007 and 2008 there won't be a single new power generation project entering the market), (iii) as if the regulatory uncertainties weren't enough, gas-fired thermo generation is facing additional hurdles regarding feedstock availability and price and many hydropower projects are on hold due to lack of environmental license; (iv) security of electricity supply is becoming a major concern and it could have devastating impacts on the expansion plans of the Brazilian industry. However Brazil could benefit from other energy sources to generate electricity in order to soften the effects of the scenario presented above. It would definitely required a solid governmental action but the country could grow significant capacity based on the following CO2-free processes: nuclear, wind, solar, wave and small hydro. By addressing the country's electricity needs, this governmental policy would make available a significant amount of biomass for the fuels industry.

For the companies that currently use biomass to produce its own electricity, the equation is easy: the desirable effect (make available by-product wooden biomass and black liquor) can only be reached if the biofuels industry gives them a greater return then paying the electricity bill – the principle is as simple as that. The linchpin here is how to make it an attractive business opportunity for them. How can this return not only be greater than the electricity costs but also be provided to them without being a burden? Shareholders and executives of the paper industry wouldn't want to spend their time and efforts proactively participating in the corporate governance of a fuel company, which is not their primary expertise field. Hence they wouldn't probably be interested in being shareholders of biofuel joint ventures together with "traditional" energy companies. Debentures, other kinds of bonds and maybe even carbon credits could persuade them to become part of the biofuels industry by ensuring additional return with minimum extra workload.

[1] Preliminary data of Associação Brasileira de Celulose e Papel – BRACELPA (Brazilian Pulp and Paper Association) http://www.bracelpa.org.br/br/index.htm

[2] To learn more about the FSC certification visit http://www.fsc.org/en.php

Even electricity generation may not be completely put aside, due to the technology of Integrated Gasification Combined Cycle (a.k.a. "IGCC"), where steam generated by waste heat boilers of the gasification process is utilized to help power steam turbines. This way the gasification step required to obtain BtL could be performed in a way that would also generate electricity. At its current development stage the IGCC process generates very expensive electricity, which has prevented a wider application so far. Nevertheless, continuous R&D activities will certainly make it cost-effective in the medium term.

3.2. Agriculture

Being a considerably developed business in Brazil, agriculture also shows great potential to contribute to the biofuels industry beyond its current participation (in the production of first-generation biofuels: "regular" bioethanol from sugarcane and biodiesel from various seeds), which is a good point to start with. Although the idea is that the country should grow its biofuel production without affecting food production, which can only be accomplished via second-generation biofuels, mass production of first-generation biofuels is a fact. With the sole purpose of producing bioethanol sugarcane occupies a large amount of arable land and despite being still relatively small there are already investments in place to harvest various seeds exclusively for biodiesel production. It's important to notice that there's a way to make these activities contribute a lot to secure feedstock supply without taking more arable land and that's, once again, using by-products. Bagasse for example represents about 2/3 of the biomass matter produced in the sugarcane cycle and it can be used to produce cellulosic ethanol. It means that the production of regular bioethanol only makes use of 1/3 of the energy potential of the generated biomass and that even if we don't use more arable land then we do today to produce regular bioethanol, ethanol production could still experience a huge growth just based on cellulosic ethanol production from sugarcane bagasse. Of course the access to this valuable feedstock supply depends on persuading regular bioethanol producers to participate in this new business and unlike the paper industry they could have interest in proactively participating in the management of the projects, pursuing influence over volumes and profit margins of the market.

There's indeed a lot more by-product biomass generated by agriculture/agricultural goods processing that one could imagine. Some good examples are (i) the hard part of the seeds that are crushed to have their oil used to produce biodiesel or cooking oils and (ii) the considerable amount of leftover peel and pulp generated by orange juice processing (and juices from other fruits could contribute the same way). Similarly to the paper industry, there are already studies in place to generate electricity from agricultural by-products. It is the case of rice hull in the southern region of the country. Such resources could be redirected to the biofuels industry if Brazil invested in other electricity generating sources, as previously mentioned.

On how we could expand this biomass contribution from agriculture, there are two interesting views worth mentioning. One of them suggests that due to progress made in cultivation techniques and improved production processes food yields per unit of land will continue to rise and the areas that are freed up could then be used for growing exclusively energy plants. Although a good concept, its application would require the constant monitoring of the food supply, in order to avoid a switch to energy crops above the limit of the freed up land. Another approach to the challenge could be dubbed "symbiotic" production, for presenting advantages both for food and for energy production. That would be developing genetically modified plant species that would maintain the original form of the produced food and together produce more by-product biomass like straws and leaves. The cultivation of solely one plant species able to produce goods destined for different purposes – food and energy – mean that their supply would fluctuate in the same way, ensuring that food production wouldn't be reduced specifically to harvest more crops for biofuels. There's nevertheless a vital point to be considered: the farmer and the biofuel company will have one more partner to share the profit: the technology company that engineered the GM plant and provided the seed. There are consequently heavy R&D costs that need to be taken into account in the project, which seriously threaten its viability.

Technology companies aside, the whole structure to integrate agriculture in the bioenergy industry must be based on the following principle: it should represent a consistent business case for farmers, who, at the end of the day, are the people able to provide biomass on a regular basis. The same remark was made above regarding the paper industry – second-generation biofuels can only achieve greater participation in the market if we can secure feedstock supply and this must be achieved necessarily via integration with other people and industries whose activities have nothing to do with fuels (except for the sugarcane industry in Brazil, which is focused on bioethanol besides sugar). Fully aware of their importance, they will naturally require a good compensation to grant access to their biomass resources. Once again it will be necessary to study on a case-to-case basis the best way to financially compensate the farmers.

It's good to point out that harvesting energy crops could be an alternative for tobacco producers, considering that the anti-smoke trend grows harder not only in Brazil but also in other countries and that it could eventually hurt their business. Shifting the current harvest of tobacco for energy plants doesn't mean reduction of food production.

Although not being technically agriculture, the activity of breeding animals destined for food processing (mainly cattle and poultry) is also performed by some farmers and it can be integrated with the biofuels industry as well. Animal by-products that are currently discarded (such as bones, fat and other tissues) and even animal manure

could be a secure feedstock supply for second-generation biofuels without interference to the food chain. It is in fact the opposite: the more food is processed, more feedstock is made available. It will be necessary once more to study how to compensate farmers and the food industry for their contribution in an attractively manner.

3.3. Other Sources

Finally there are other sources of biomass in our everyday lives that could certainly be destined to production of biofuels. That would be mainly public yards and trees trimmings, wooden and paper-made packaging material and wooden debris generated in demolitions. Even sewage can be used. Albeit they lack volume and regularity of production to be considered a secure source, not using them would be definitely a waste of energy. Considering the unreliability of these supply sources, it is very difficult to find a way to financially compensate their providers regularly via a formal agreement, like it is proposed for example for the paper and the food industries. The major driver for this kind of contribution would have to be the public's "green" conscience and, consequently, the willingness to promote sustainable development and environment protection.

4. Collecting, Processing and Marketing Logistics

Transportation methods and distances to the conversion plant have a strong impact on the final cost of the biomass-derived fuel and on the CO2 footprint of the chain. Biomass from forests and agriculture are usually distributed over a large area while conversion into fuel would occur at specific points. Furthermore the concentration of energy per pound in biomass is significantly reduced if compared with fossil fuels. Consequently, the concept of "economy of scale" is hard to apply to the second-generation biofuels production chain: one big centralized production unit would require a huge amount of feedstock supply and in order to collect it biomass would have to be transported from distant places, generating costs and CO2 emissions (considering traditional diesel-powered trucks transportation). It makes more sense to obtain the same production volume of a big unit through several smaller units that process locally generated feedstock (what would not only mitigate costs and CO2 emissions to receive feedstock but also to distribute the fuel to the final customers/filling stations, considering that they would receive the product from the geographically closest unit). Since the proposed structure is to employ currently underused biomass, which would be a relatively low-value commodity, transportation costs would represent a large part of the total production cost. The structure composed of small production units is also more convenient for safety and supply reliability issues: big fuel processing units like refineries are exposed to serious accident risks due to their large daily production volumes and in case the whole facility needs to be shut down a great number of costumers would be affected because the refinery is usually in charge of the supply of an wide-ranging geographical area.

5. Required Actions & Conclusions

Similarly to the development programs of first-generation biofuels (i.e. bioethanol and biodiesel) the kick-off must come from the government via the issuance of a specific policy/regulation regarding second-generation biofuels – due to their importance they deserve specific rules. It is not enough that conversion technology is internationally available. It is not enough that high oil prices make biofuels production become each day less dependant of subsidies, as consequence of rising gasoline and diesel prices. It is not enough that the bioenergy market attracts not only the major energy companies, but also several new companies specifically incorporated for this purpose and with solid financial structure. No one but each country's government has the power to coordinate all these factors by putting in place a solid policy to attract private investors and turn ideas into reality; projects into investments.

As mentioned before, biomass is a feedstock suitable for the production of either high quality transportation fuels or electricity. Thus in order to make it available for second-generation biofuels production the first point that needs to be addressed is the growth of the electricity generation capacity based on other sources than biomass (and preferably also CO2-neutral): wind, solar, nuclear, wave and small hydro. Even thermo generation could be stimulated if natural gas is replaced by biogas or bio-oil as feedstock. Meeting Brazil's electricity needs in this way will discourage biomass utilization for this purpose.

Specifically regarding the second-generation biofuels policy, it is vital to have particular rules because of its major advantage: no interference to the food chain. Even though Brazil has great potential to produce biofuels – either first or second-generation – this blooming market cannot overshadow the extreme poverty of a significant part of the country's population. We can't accept that the biofuels industry keeps growing bigger while undernourishment is spread through the country. This unique feature of the second-generation biofuels – their feedstock can be produced together with food – makes it the best option for use in transportation and hence deserves a more advantageous regulatory framework for its production. Even in the cases that biomass doesn't come from the food industry or agricultural activities destined for food (for example the paper industry and bagasse from sugarcane production), not

using it represents a major and unacceptable waste of energy. As such these cases also deserve to be included in the scope of a beneficial policy.

There are a variety of ways to stimulate the creation of a market for second-generation biofuels, apart from the traditional ones. For example to establish the prevalence of BtL over biodiesel in the mandatory mix of biofuel into regular diesel. The substitution targets would be segregated for the two kinds of biofuels, being BtL the only fraction that would grow (but also ensuring the participation of biodiesel to preserve investments that have already been made). Example: in 2010 the new biofuels substitution target could be 10% mixture in regular diesel, being 5% of BtL and 5% of biodiesel. In 2020 the target would be raised to 20%, being 15% of BtL and 5% of biodiesel. A simple substitution target, like we have today for biodiesel into diesel, could also be created to promote the mixture of cellulosic ethanol into regular bioethanol (2.5% in 2010, 5% in 2015 etc). Of course the numbers mentioned here have the sole purpose of illustrating the proposed concepts. The actual numbers to be included in a policy should take into consideration the second-generation biofuels production ramp-up curve.

Even though the technologies to convert biomass into fuels are already available internationally, they're still in early market-scale application stage, existing room for improvements and further developments. These Research & Development costs are traditionally borne by the private entrepreneurs, whose investments in technology intend to (i) offer to customers a product that has good aggregated value and is yet affordable, and (ii) guarantee the rights over developed processes that can be licensed to other competitors. In order to make part of this R&D investments flow into Brazil, it is very important to stimulate scientific research in domestic universities and other technology centers, so that the country can offer capable human resources to integrate this industry.

Considering that agriculture and forests are major biomass sources, another issue of vital importance to be addressed by the government is security in these production areas, specially threatened by actions of the "landless movement" (known as "MST"). It's been already mentioned that a very large part of the Brazilian population live in very bad conditions and there's absolutely no doubt that at least part of these people could and should be given small rural properties and affordable credit to be integrated in the agriculture business (and simultaneously reduce unemployment rates in the biggest cities). On the other hand invasions and other kinds of violence against lawful properties, in many cases politically driven, are completely unacceptable.

The mass production of biomass-derived fuels would stimulate the discussion of a very exciting issue to be led by Brazil: the possibility of carbon credits issuance related to biofuels production. Strictly it would not be possible because when biofuels are burned they do produce CO2. Nevertheless one of the most important advantages of biofuels is that they "close" a CO2-neutral cycle (as biomass employed in the process absorbs the CO2) while fossil fuels release "additional" carbon in the atmosphere that exceeds the planet's "absorption capacity". Therefore it is very reasonable to pursue the implementation of mechanisms that allow the issuance of carbon credits for biofuels production and private investors will be very much interest in it.

Finally, the destination of domestically produced biofuels needs to be seriously considered. Export plays have noteworthy importance because they can unlock investments that the country's domestic market alone wouldn't be enough to justify. On the other hand, Brazil must continuously pursue the sustainable development of its economy, what means growth of energy demand. The issue that will need to be sorted out by the government in the future is how to ensure respect to the long-term export agreements and simultaneously ensure plentiful supply and stable and low prices in the domestic fuels market. As we've mentioned, the commitment to meet rising energy needs comes as consequence of a more important pledge: ensure that economic growth comes with wealth distribution.

Actually equitable development and wealthy distribution in developing countries are not merely expressions typically used in political campaign, but one of the foremost interests of private investors. Tough competition and stagnation in the developed economies made them realize that excellent business opportunities could be unlocked if developing countries became not only sources of cheap workforce, but also reliable customers of goods and services. For example: persuade the young Chinese to be the first one to buy a car in his family (and consequently buy fuel, replacement parts etc); make the Indian retiree buy a laptop to spend this free time browsing on the internet (making him a customer of broadband internet access service, a potential customer for online shopping and consequently a potential customer of express delivery services, besides demanding additional electricity generation in the country). The quality of life of these people is not really the main objective of private companies, but this aspect is now given importance because it was acknowledged as a useful tool to enlarge their consumer base (and the return of their shareholders). This perspective goes indeed a lot further than the much-hyped duo China-India. There are potential customers waiting to be "integrated" in almost the entire African continent, in Latin America, in Eastern Europe, in the Middle East countries – but the first step towards the integration must come from local governments by making available good quality infrastructure, strengthening regulatory institutions and investing in education.

The industry of second-generation biofuels in Brazil has the potential to be one of these cases of converging interest and mutual benefits for the local community and private companies. The way its production chain can be integrated with other businesses means that the more pulp, paper, fruits, crops and animal-derived food we process, the more we'll be able to produce it. This is particularly important because it enables the country to simultaneously meet rising demand for all these goods and to offer them not only in the domestic market but also in other developing

countries (we must bear in mind that while some of their inhabitants are buying their first cars, enlarging the fuel market consumer base, others are actually buying good-quality food for the first time, expanding the market for the Brazilian agriculture and food processing industry). It's a unique opportunity to generate jobs, create a production chain of products with good aggregated value and offer an environmental-friendly sustainable source of energy to support the country's development. Given the magnitude and the good prospects of ventures in this area, if the government fails to deliver the necessary framework, it is in their legitimate interest if other stakeholders, including society itself, promote discussions to encourage it.

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