Introduction

The energy sector is going though considerable upheavals for a combination of factors e.g., climate change, environmental pressure, decarbonization, and the Russian war on Ukraine. The time where little used to happen is gone. Take, for example the oil sector, and more specifically transport, which has not been synonymous of rapid change in the past. In fact, for decades, hardly any significant change took place. For decades, the automobile industry and oil and gas giants, have shared a married of convenience.

The undergoing changes are unparalleled. The energy sector is generally very volatile, and this situation is further compounded by the Russia-Ukraine war. Oil volatility is rife, with market dislocation increasing. This, together with surging energy prices will curb demand, at least in the short term.

There are many "unknowns" but undoubtedly such changes represent a paradigm shift with cataclysmic proportions. Huge economic, social, environmental and policy implications, with hundreds of billions of dollars are at stage. Such changes represent both huge opportunities and also unprecedented challenges and pitfalls.

What is then the likely energy scenario in the near future? This is clouded with uncertainty. There are not clear enough energy trends to predict, with reasonably degree of certainty, what may happen in the next 10-20 years, not to mention beyond this. There have been many scenario predictions but hardly any have turned out to be correct. Let focus on transport. There is no question that the automobile of the future will be very different, in which decarbonization, environment and sustainable fuels will play a key role.

The energy transition will be largely conditioned to advances is decarbonization, which, at the same time, will be affected by many and diverse factors, e.g., political,

economic, environmental, social, and technological. Such changes will be uneven throughout the world. This involves a multitude of mutually supporting measures. Climate change abatement requires a minimum of global cooperation. Unfortunately, this is an area characterised by huge differences between the most advanced economies versus the poorest ones. The replacement of fossil fuels by renewable energy (RE) will be uneven around the world. For example, in some countries electric vehicles are already well underway, as are biofuels.

These impinging changes represent an enormous challenge to both the automobile and oil and gas industries, as stated. While oil and natural gas are not going away any time soon it will, progressively, be phased out over time. And many candidates are progressively emerging e.g., electricity, hydrogen, solar, biofuels (bioethanol, biodiesel). In the future there will be a mixture of fuels in which none will be playing the dominant role of oil. The question is which ones will prevail in this arras of possible alternatives. Only time will tell.

At the time of writing, it is impossible to predict with any degree of certainty what will be the real impact of Russian war on Ukraine, except that the impact will be felt for a long time and unequally around the world. The old system is being replaced without a clear vision of what will be put in its place. This is particularly the case in Europe with is highly dependent on Russia for fossil fuels and is urgently trying new sources and alternatives. Time will tell.

But at the same time, there are reasons for optimism. Human ingenuity has almost no limits. We are facing huge problems, but never in history are so many researchers and resources dedicated to find solutions. New technologies and innovations are advancing exponentially. A clear example has been the search for the COVID-19 vaccines, which in normal times would have taken years to develop, but in reality, took months. Another example is UN COP26 in Glasgow and COP27 in Egypt. And a further example of international cooperation is the UN Convention on Biodiversity, 7-19 December 2022, in Montreal, that has agreed to Adopt a Global Biodiversity Framework. Despite huge difficulties, it has been possible to reach some fundamental global agreements, that affect the global community. Of course, it remains to be seen how this will translate in fundamental and real actions.

It shows that when Homo Sapiens confront a serious problem are capable of finding solutions. Without forgetting the human stupidity and capacity for self-destruction. With the energy sector could be the same. After all, the most complex thing we know in our universe is the "human brain". A simple, immediate, and cheap solution is for all of us (particularly those who consume a lot and waste even more) to use less energy, without negatively affecting our living standards. We all can make choices and many small choices amount to a big one. As Gandhi, said: *There is enough for everybody needs but not everyone's greed.* The new reality requires bold decision-making and political brinkmanship!

This book is concerned with the potential role of biofuels in transport, one of the alternatives being pursued within this changing energy scenario, with Brazil as the key focus. Why biofuels? Because they have been around for many decades, and in

particular in Brazil and USA, and to a lesser extent in many other countries. They represent a proven alternative, be it limited. Biofuels represent little technological challenge by comparison, as it is a well proven technology and fuel. The pros and cons of biofuels have been heatedly debated, but on balance and, if produced and used sustainably, the benefits far aweigh the negative impacts. Therefore, biofuels represent a considerable advantage over other emerging alternatives.

Biofuels have been around for decades and are an integral part of the fuel mix in the transportation systems. Currently this sector provides between 3-4% of fuel consumption in road transportation, with USA and Brazil as the main producers and consumers, and to a lesser scale in the EU, China, and India, among others.

Unlike petrol, the use of biofuels is patchy, and their contribution on a global scale is unequal, representing a minuscule contribution, or none al tall, in many countries. This uneven distribution reflects resource endowment, and policy options, cultural factors, lack capital, know-how, etc. The totality of biofuels is used blended with petrol and diesel in varying proportions. But we cannot forget that biofuels, particularly ethanol, have multiple other industrial uses.

The question we are posing here is, the extent to which biofuels are likely to play in a rapidly changing energy scenario? To what extend the paradigm shift will enhance or inhibit their development, as oil is gradually replaced by other emerging alternatives, in addition to biofuels, e.g., electricity, hydrogen, solar, etc? And most importantly, what role can biofuels play in Brazil in the future?

Growing concern with climate change, environment, and sustainability, together with social and political pressures, means that this paradigm shift cannot be reversed. On the contrary, it will accelerate. Climate change is a growing concern and the huge potential impacts have not yet fully penetrated into the majority of the population psychic, who is struggling with everyday life and regard climate change as something that may happen in the future.

But biofuels have also negative effects that limit their potential. The main one being the perception of land competition with food production and the requirement of being environmentally sustainable. The "food versus fuels" dilemma has been the object of heated debate for decades. The debate has been clouded by vested interest, bias, and lack of reliable scientific data. The "food versus fuel" debate needs to consider the intertwined nature of biofuels, land use, food production, food waste, animal feed production, diets, social habits, food distribution systems, policy, etc. In fact, the FvF argument is being discredited, even in the EU where there has been a strong debate (see Chapter 6).

The biofuel industry needs to transform itself and get rid of the FvF argument, even in Brazil where this has not been a serious issue. Biofuels production needs to be complementary to food production.

Biofuels have still mountains to claim, but new technological developments e.g., converting cellulose-based biomass to ethanol, will make available large additional

amounts of feedstocks in many more countries, at competitive cost in the near future and on a sustainable manner.

What then are the potential opportunities and challenges confronting biofuels in this rapidly changing energy scenario? Should biofuels be promoted as a vehicle fuel or should the focus be on new emerging markets e.g., aviation, maritime transport, or fine chemicals? This will depend on the specific circumstances. The book investigates such potential alternatives with focus in Brazil.

Biofuels will not be the answer to oil, but they can play a much greater role as it has been the case so far in the fuel mix. This is particularly so in the Brazilian case. Understanding such trends will provide a better world view on these changes. And just keep in mind that there is not, quite simply, a 100% pollution-free fuel; just fuels than pollute more than others.

Five central themes are the main focus of this book.

Firstly, it provides an overall global view of the energy sector and the changing scenarios and the role of biofuels within it. No country is an island and what happen in the world will have an impact in Brazil, directly or indirectly, and in a minor or major scale, and vice versa. This overview will help you to better understand the current and potential directions of the energy sector, primarily transport.

Secondly, the book examines the history of biofuels development in Brazil. The history of ethanol fuel is fascinating, with many twists and turns. No large program is exempted of human desires, views, vested interests, political infightings, and so forth. There are important lessons from this unique historical experience.

The third theme describes in great detail the present situation of biofuels in Brazil (ethanol and biodiesel), ranging from current status, opportunities and challenges facing this industry and wider implications. Major changes are underway e.g., the rapid expansion of corn for ethanol production, challenging the dominant role of sugarcane, or the utilization of soybean oil for biodiesel production. The potential changes in the transportation system with new fuels e.g., electric cars, hydrogen, etc., are leading to new scenarios.

Theme four focuses on the fundamental R&DD required to overcome the challenges. It demonstrates that Brazil has considerable R&DD capacity and know-how to develop new feedstocks, particularly from woody biomass, and process technologies.

The final theme (Chapter 5) focuses on the future of biofuels in Brazil and try to answer the fundamental questions posed in the book. It seems that a key issue will be political rather than anything else.

And finally in chapter 6, we summarize the key points covered in the book. This chapter provides a succinct and quick overview, together with final thoughts.

Why this book, the reader might ask? This book has been born from the desire to explain to the non-expert in biofuels, and in particular the international community, of their importance. To share the authors rich experience over many years with the

development of biofuels, and to provide a better understanding. It is aimed at a wide readership, from the policymaker to the general public.

We live in a world inundated by scientific data, rapid technological change, misinformation, (often beyond human comprehension), that confuse the reader; a world where the only thing we all seem to agree and matters more (between friends and enemies) *is money*. Throwing a bit of light should help the reader to better understand the world of biofuels and their merits and implications.