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ORIGINAL PAPER

Distributing Responsibility in the Debate on Sustainable Biofuels

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Abstract In the perception of technology innovation two world views compete for domination: technological and social determinism. Technological determinism holds that societal change is caused by technological developments, social determinism holds the opposite. Although both were quite central to discussion in the philosophy, history and sociology of technology in the 1970s and 1980s, neither is seen as mainstream now. They do still play an important role as background philosophies in societal debates and offer two very different perspectives on where the responsibilities for an ethically sound development of novel technologies lie. In this paper we will elaborate on these to two opposing views on technology development taking the recent debate on the implementation of biofuels as a case example.

Keywords Technological determinism · Social determinism · Social constructivism · Technology · Innovation · Biofuels · Public debate

Introduction

In Europe, the central driver for biofuels in the public arena was sustainability. This was closely associated with concerns to counter or slow global climate change. Issues were raised on changes of land use (food versus fuel), energy efficiency, economic feasibility and the distribution of wealth between the North and the South. Another important driver, neglected in Europe but central to the debate in the United States, was energy security. This one-sided emphasis in the public debate seems to have led to public opposition to the implementation of biofuels.

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In 2008, the Dutch Kluyver Centre for Genomics of Industrial Fermentation's Programme for Biotechnology and Society co-hosted two stakeholder debates on sustainable biofuels open to the general public. The first was held in Amsterdam, the second in Rotterdam. The two debates were entitled '*Perspectives on Biofuels*' and were mediated by a citizen's initiative entitled "Parrhesia.nu".[1] The debates we organised from the perceived need for interaction between research centres, other stakeholders and the public about research agendas. Rather than 'explaining science to the citizen', the aim was to gain greater insight into the societal implications of innovation in industrial biotechnology, in this case with specific attention to the debate on biofuels. The debates aimed for informed discussion of policies for sustainable biofuels so as to be able to reach a higher level of quality in the decision making process, specifically in relation to the making of policy. They therefore brought together a wide range of stakeholders to bridge differences in priorities and interests in developing a mutual and ethically justified, as well as economically viable, agenda. The outcomes were used to inform a stakeholder workshop on societal aspects of the development of biofuels and the European parliament on the societal issues that are relevant for the implementation of biofuels. For the debates, secondary stakeholders were invited to contribute to the discussions. The audience of both meetings consisted of: smaller industrial biotechnology companies, companies working in the fuel trade sector, representatives of the transport sector, petrol station proprietors, car lease companies, representatives of the Rotterdam harbour company, engineers, social scientists, NGO's (both with a social and with an environmental focus) and policy makers. The meeting in Amsterdam discussed issues of policy making and criteria for sustainable energy production, that in Rotterdam the economic and practical viability of such criteria.

The initial enthusiasm about biofuels demonstrated the belief in a "technological fix" for the problem of the greenhouse effect, the polluting nature of fuel engines and other forms of energy use (coal or oil-fired electricity generating plants, for example) and the seemingly imminent depletion of fossil fuels. The subsequent negativism about biofuels showed distrust in such technologies seen as the socio-economic drivers behind their development. The multitude of positions brought forward during the debate about the implementation of biofuels could similarly be reduced to two main views: technology as the primary driver for societal change, and society as the primary driver for technological developments. Both lead to an evaluative rather than a goal-orientated view on technology innovation. A third view takes into account the complexity of the issue at hand, rather than reducing it to one mono-causal framework. In this paper we will elaborate on these by means of two extremes in the study of technology: technological and social constructivism. We will regard them as articulations of implicitly held views of technology innovation in society. In the past decades, more nuanced positions in the sociology, philosophy and history of technology have become mainstream in the academic world. With this reduction of the wide range of theories on the interrelation between science, technology and society, this paper does not do justice to the current debate. This however, is not the intended goal of this paper. Here we use social and

[1] See www.parrhesia.info for an account.

technological determinism seeing their role as implicitly held frameworks of perception in the debate on sustainable biofuels.

Technological and Social Determinism: A Backdrop

Technological determinism is an approach that was made explicit in the 1970s although it was implicitly held prior to its articulation as a distinct approach to the development of technology. It holds that technological developments lie at the basis of societal changes. Social determinist approaches, such as Marxism, social constructivism or cultural determinism, hold that social factors influence technological change and the development of technological artifacts. Strong versions of both technological and social determinism came to be refuted in the history, sociology and philosophy of science and by the 1990s it became more common to sketch a dialectic relationship between technology and society (e.g. the concept of a coevolution of science, technology and society as it was presented by Callon et al. and Stankiewicz)[2,3] The two determinist views now exist mostly as implicit paradigms in societal debate. In this paper we will try to shed some light on the influence of these two perspectives on technological development and their influence on the perception of responsibilities over the potential consequences of novel technologies. We will also investigate the influence of these two perceptions of technology on the current discussion on the implementation of second generation biofuels. We will then look at how to approach such issues more constructively with regard to responsible technology innovation.

Technological determinism holds that technology drives social change as if it were a force of nature without us being able to intervene in the process. Technological determinism was not made explicit till the 1970s in the context of a technologically internal interest in the history of science and engineering. This discipline did not spring from history but rather from scientists and engineers. As Chandler mentions, technological determinism sprang from the history of technology, which originating as a sub-specialty of the history of science, was at first dominated by engineers and other 'design-oriented specialists' interested in machine design technology and in celebrating the impact of successful technologies on Western societies.[4] Due to the fact that technological determinism sprang from a technology-internal perspective, the development of technological systems is regarded as a first cause for societal change, whilst this development itself is steered by the process of applying knowledge and refining engineering skills.

In technological determinism, technologies influence society. In addition, technological development is seen as an exclusive cause of societal change. Other influences such as political, natural or ideological ones are dismissed or again reduced to technological factors. In technological determinism, technologies such as printing, the steam engine or genetic modification determine societal change.

[2] See Callon et al. (1992).

[3] See Stankiewicz (1992).

[4] For an example, see Sicilia (1993).

Without technological inventions, society would not have changed since the Middle Ages. In traditional technological determinism the development of novel technologies is determined by the progress of science. In this latter view there can be no responsibility over technological developments since these developments will proceed anyway. An example of this type of determinism is the deterministic view on the invention of nuclear weapons. The argument runs as follows: physics discovered that the atom was not the smallest particle but that it could be further subdivided into a core (consisting of protons and neutrons) and circling electrons. If one splits the nucleus of an atom into parts, specifically into heavy elements such as plutonium or uranium, an exothermic reaction is caused which releases large amounts of energy in the form of radiation and kinetic energy. This scientific discovery (meaning that one had a better representational model of nature, derived from experiment) opened up the possibility of manipulating nature on that level as well. This is then necessarily supposed to culminate in the development of the atomic bomb. Within this perspective, scientific discoveries are determined by the nature of the external world and technology uses the insights of science to develop new artefacts.

For technological determinism technology in its turn, shapes society and social progress. This view should not appear strange in relation to for example the industrial revolution. The invention of the steam engine spurred societal change (not unequivocally accepted as progress) that was until then unprecedented. Similarly, the limits of the Roman empire could not be stretched further due to the lack of a mode of transport faster than the horse, the discovery of the Americas was only possible in a society that discovered that the world was a sphere rather than a pancake combined with new navigation techniques, the Middle Ages ended with castles becoming obsolete due to the invention of gun-powder, and the First World War ended up being a disaster because of the introduction of new kinds of weaponry. Of course there is room for different applications of the same knowledge, but in essence, it is the technological state-of-the-art that makes developments possible and without them societal development would grind to standstill.

The relation between science and technology as a mono-directional, causal influence leading from discovery in the form of scientific facts, that can be related to each other as laws, to use and apply in the form of artefacts, from episteme (knowledge) to techne (craft or skill) is not taken for granted by all. Technology can be seen as the outcome of scientific progress but it can also be regarded as its condition.[5] One often needs technological artefacts to discover new scientific facts and a scientist needs at least some technical experience to conduct his or her job properly. The discovery of the bacterium would not have been possible were it not that Antony van Leeuwenhoek invented the microscope and thereby demonstrated a scientific fact that previously existed merely as philosophical speculation. That technologies can also influence science holds several consequences for the supposed deterministic nature of technological developments and their supposed influence on society. The increase of knowledge as well as craft or skill would need to be viewed from a less determinist perspective. In that case one is forced to acknowledge the

[5] As defended by Gardner (1994).

responsibility of the engineer. His inventions are not predetermined by scientific discoveries therefore he needs to take responsibility for the consequences of his actions. From this perspective, responsibility over the consequences of novel technologies on society is put solely in the hands of the engineer. For the technological determinist, science and technology are the guardians of societal welfare and progress. The scientist's responsibility consists of conducting sound scientific research. This responsibility does not extend to the usage of science and technology for purposes it was not designed for.

Technological determinism was criticised from the outset, specifically from the rising field of the sociology of science and technology. From the 1970s onwards it was questioned whether technological developments spur societal change as a first cause. One of the more important exponents of this criticism of technological determinism was Bruno Latour. He asked questions of the like of "What spurred the invention of the steam engine or the invention of gun powder?" And after all, gun powder had been around in China for ages, without throwing Chinese society into a new era. Latour held that scientific knowledge is not historically but socially constructed.[6] Scientific facts and statements can therefore not be seen to refer to anything outside the vocabulary that is introduced by the instruments in the laboratory and the traditions within which they, and the results they produce, are interpreted. Therefore, science is not about principles and norms that further the growth of knowledge about some external world, it is merely a culture. Social constructivism became an alternative view. Social constructivism is a field that was initially dominated by social determinism. For the social determinist, all is socio-culturally determined. History is not determined by the mechanisms of a yet more basic sphere but merely by societal vectors. This includes the history of science and technology. The driver behind that history is society. This view perceives of science and technology as normatively burdened rather than neutral. Within their perspective social determinists see society as shaping (science and) technology, rather than the other way around. In social determinism, specifically social constructivism, it is not nature or reality but social and cultural norms and conventions that steer the development of scientific knowledge and its application in technology. Whether a technology works is not dependent on the degree of success in instrumentalising nature but on its level of acceptance in society.

For the non-initiated, Bruno Latour seems to support the idea that the earth was indeed in the centre of the universe before Copernicus and Galilei pleaded for heliocentrism. This is untrue. It is rather the case that social constructivism does not interpret science as the quest for true knowledge, nor does it see technology as the application of such 'true knowledge'. In one of his earlier works, social constructivist Wiebe Bijker stated: "*Philosophers tend to posit over-idealised distinctions, such as that science is about the discovery of truth whereas technology is about the application of truth. Indeed, the literature on the philosophy of technology is rather disappointing. We prefer to suspend judgment on it until philosophers propose more realistic models of both science and technology*".[7]

[6] The classic approach can be found in Latoru and Woolgar's 'Laboratory Life'.

[7] See Bijker et al. (1987).

The social constructivist perspective seems to hold a more promising ability to manipulate science and technology or social and cultural norms in such a way that developments therein gain in level of acceptance. Resistance to new technologies and the artefacts that they produce as well as refusal to use them lead to the modification of such technologies. Examples from Nelly Oudshoorn's "*How Users Matter*" include the introduction of the telephone into rural America and the influence of non-users of the Internet.[8] One is expected to be able to steer the development of novel technologies by taking into account the role of users in different phases of the development, testing, and marketing of new technologies. Phillips for example, developed a 'ladyshave' for users that were assumed to be technophobic.

As Transvik and MacKenzie state, both views of technological and social determinism appear to be mutually exclusive.[9] In his *Beyond the Black Box*, Flyverbom gives also an account of this traditional picture of technological and social determinism as two mutually exclusive ways to look upon technology development.[10] He does not agree with it. As Flyverbom stated in his paper "*Beyond the Black Box*" they are only mutually if one assumes that they both study the interrelation between science and technology from a similar metaperspective. But in Flyverbom's view technological determinism and social constructivism are actually studying two different things: technological determinists study the material aspects of the relationship between science and technology whilst social constructivists study the ideational aspects of that relation.[11] As true as this may be, the perception of the division of responsibilities is opposite. Where social determinism leads to a view in which responsibilities over technology lie with society, technological determinists, as far as they accept that technologies are in themselves not determined too, would put responsibilities for technological developments with the engineer.

It is not the central aim of social constructivism to logically refute the objectivity of fact. It is merely that in the light of the apparent socio-cultural construction of scientific facts in the past, we are forced to reconsider the attention we have been giving to the status of current scientific facts as truths. In social constructivism, scientific facts as well as technological artefacts are regarded as the product of social interrelations rather than of some kind of congruency, or the application thereof, between linguistic utterances (scientific laws) and the external world.

Within a perspective in which the development of novel technologies is seen as merely dependent on the developments of scientific knowledge (as representationalist), one cannot account for many features of novel technologies. Social constructivism provides for an interpretative framework in which such aspects can better be explained: the rise of the modern bike and the decline of the penny-farthing, the design-features of a ladyshave etc. With social constructivism it is much easier to get a view on why a certain technology gets to be embedded

[8] See Oudshoorn in 'How Users Matter'.

[9] See Tranvik et al. (1999).

[10] See Flyverbom (2005).

[11] Ibid.

successfully in society where others do not. But, as Langdon Winner already stated in 1993,[12] social constructivism cannot give an account of how technologies in themselves are influential again on society.

One might be able to analyse the socio-cultural background of the success or failure of a new theory or of a new technology after the fact, but since these are highly complex processes, one cannot easily use such an approach to predict or steer the success of a novel theory or technology beforehand. To know in what way the development of a technology was socially construed is one thing, but to use this knowledge again to steer technology innovation is quite a different matter. Can one assume that one can know all factors that are of influence on this coevolution, one can predict and therefore steer the success of novel technologies? To cut this process short by trying to intervene might be detrimental to innovation and the development of novel technologies.

From a social constructivist perspective, social constructivism in itself is a theory that would have to be subject to the same socio-cultural determinants as any other science or technology. This position that stark relativism refutes itself in the end is as old as the first critics of the ancient Greek philosopher, Protagoras. He stated that everything was relative, but in stating this he would either have to admit that even that statement was relative, or that not everything was relative. In either case, one ends up with the conclusion that indeed not everything is relative. Some might find this logical refutation of relativism merely an issue of rhetoric. But it does have several consequences for the validity and usefulness of relativist approaches: the outcome of a socio-cultural construction of the success of a technology would after all be dependent on the subjective perspective, preferences and prejudices of the social-constructivist in question. In that case, how can these outcomes state anything sensible about technological developments?

Dividing Responsibilities in the Implementation of Biofuels

Until now fossil fuels have played an important role in our society. Gasoline, diesel and LPG have satisfied the need for high energy transportation fuels whilst coal and oil are also used for the generation of electricity in power plants. Due to some important drawbacks of these fuels this situation is changing. For one, fossil fuel resources will be depleted inevitably at some time in the future. A more pressing matter is that usage of fuels derived from fossil oils or gasses pollutes the environment, and is the main responsible for the greenhouse effect. In 1996, transportation was responsible for some 28% of the gasses that cause the greenhouse effect in the EU and if our economy develops as expected, CO2 emissions are expected to have increased by 50% between 1990 and 2010.

The EU and its Member States committed to the reduction of their CO_2 emission to counter the greenhouse effect and ratifying the Kyoto Protocol in May 2002. The protocol acknowledges the importance of the problem of climate change[13] and

[12] See Winner (1993).

[13] See Malça and Freire (2006).

requires that industrialised countries reduce the emissions of six greenhouse gases (CO_2, which is the most important, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) to an amount that is 5.2% lower than the 1990 level. This aim is to be reached during the first commitment period, which lasts from 2008 to 2012, but the EU Member States agreed to reduce the greenhouse effect from 2008 to 2012 by more than 8% below the 1990 levels. Several governments drew up new policy lines to give incentives for the implementation of biofuels. The approach is to introduce biofuels to the market in the short term by providing subsidies and facilitating bank loans, changing the current infrastructure and researching new production methods. Progressively more biofuels are therefore used instead of fossil fuels.

There are also drawbacks to the implementation of biofuels. Firstly, fuel production might be at the cost of food and feed production[14] since currently the production of biofuels is still highly land intensive. Although the ethical discussion within Europe is also concerned with this competition, the consequences for less-industrialised countries are likely to be much more severe. And it is to be expected that most crops for biomass-production will be imported rather than grown in Europe, since Europe probably will not be able to put enough land to use and to grow crops cheaply enough internally. Therefore, regions that already have to cope with food and feed shortage might suffer directly from our need for biomass. A second objection often raised concerns the actual yield of biofuels with respect to decreasing greenhouse gas emissions. Biofuel-mass production is already damaging the environment in several countries. In some cases, rain forests are cut down to create land for planting oil palms. Furthermore, the transportation of biomass to locations for refinery and biofuel transport itself uses up fuel as well as aiding to produce new fuel. This is a factor that might seem irrelevant since fossil oil also needs to be transported and refined. Thirdly, there is no clarity yet on the economic compatibility of biofuels. This means the expectations might be set to high. The import of bioethanol from for example Brazil is not under embargo. Furthermore, the bioethanol market fluctuates rather severely, and Brazil offers their bioethanol more cheaply than local producers can afford to. Therefore it will be difficult to compete with producers outside of Europe with home-grown cane and home-made bioethanol. However, it is not clear whether bioethanol production outside Europe is too environment-unfriendly to serve the purpose it purports to serve. It might reduce CO_2-emission on a national level but not on a global level. Because of this, the debate on the implementation of biofuels as a means to reduce the emission of CO_2 is becoming more and more polarised.

In the societal debate on sustainable biofuels, initial enthusiasm was mainly fed by engineers defending the transition from a fossil-fuel-based economy to a biobased economy as solving the imminent problem of the greenhouse effect. Biofuels were made out to be a solution to a multitude of economic and environmental problems. After initially having been hailed as the Holy Grail for solving the problem of the greenhouse effect, enthusiasm on the development of novel biofuels has been tempered. This trend is visible in the media and influences

[14] See Wakker (2004).

the opinions of the public at large. Even though both government and industry are aiming at implementation of biofuels in the short term, there is still much that is unclear about whether this implementation will indeed serve the goals it is made out to serve. One can ask whether the introduction of biofuels is not merely an example of a too fundamental belief in technological fixes for societal problems whilst such problems could also be solved on the level of society itself, whilst such a fix in practice does not solve the problems it is supposed to solve.

From the debates on biofuels, we harvested the most striking claims and lines of discussion to serve as input for an expert stakeholder workshop with the aim of drawing up a list of policy recommendations for the European Parliament. The results of both the debates and the workshop were discussed during a dinner debate for members of the European Parliament with specific interest in issues related to the implementation of biofuels such as climate change, sustainability, agriculture etc. During the debates, two opposing views appeared to be unproductive in defining norms for the development of sustainable biofuels: that one can solve all problems of environmental, climatologic, social, logistical and economic problems associated with biofuels by biotechnological development or that biotechnology is causing, or adding to, these problems whilst the actual solution lies solely in societal adjustments.

During the debate, most people with an engineering background defended the idea that citizens could rest assured that engineers will inevitably find a solution to the problems associated with biofuels. Generally an engineer will implicitly hold to technological determinism, believing that technological development is a linear process of separate phases running from scientific discovery to the development of practical applications thereof, then being introduced to users in society. This was supported by the results of a series of interviews conducted to serve as additional input for the stakeholder workshop.[15]

Since the 1960s bioengineers have pushed for the introduction of biofuels to the market. Biofuels are therefore a classic example of engineers explicitly pushing for societal change. Climate change was caused by the usage of the diesel engine, while the key to halting this change also lies with the engineer, not by 'reinventing the wheel' but rather by changing that which causes it to move. Responsibility for the change in climate lies with the engineer. Solutions to this problem therefore also lie with the engineer. This however does not mean that engineers have the overview to assess which technology would be better than another. As Woodhouse defends: "*How can scholars with a broad range of motivations collaboratively extend technoscience studies so as to focus more insightfully on barriers and prospects for designing, constructing, and diffusing technologies differently—without presuming that any one scholar or subgroup of them has the right or capacity to define what constitutes better?*" There were also many participants who voiced the idea that societal needs and preferences lead to the development of novel technologies. Under influence of several societal drivers, biofuels came to be seen as an interesting option. The main social drivers behind the development and implementation of biofuels were perceived to be: our increasing need for energy; agricultural lobbies in

[15] Unpublished data from the Kluyver Centre.

France and Germany pushing for new ways to gain subsidies; politicians "putting on their green face"; Russia and Arabia being perceived as less stable regions on which to be dependent as sources to meet our energy demands. All these 'hidden drivers' of the implementation of biofuels demonstrated how public perception of biofuels changed from "Holy Grail of sustainability" to "scapegoat for personal and corporate interest". At best, the engineer was seen to be naïve, at the worst as part of yet another interest group. Many participants therefore claimed we should modify our *needs* for energy, rather than its source and rather than satisfying our needs by introduction of novel technologies. The problem created by use of fossil fuel is societal (i.e. usage as such). Therefore, its solution is also societal (i.e. make people use less transport).

It is no myth to think novel scientific discoveries will lead to novel applications in engineering. Nor is it a myth to think that the products of engineering can lead to major changes in society. It is however a myth to think that the road from science through engineering to society is mono-linear. These products need to go through processes of acceptance and adjustment to be able to become implemented in society. Problems of a practical as well as a cultural and political nature have their role in the acceptance or rejection of a novel technology. As was stated during the debates: "*Experts have only knowledge about mini-causalities but the larger scope and technology external issues are often left aside since they do not match the (scientific) paradigm*".[16] Success of a novel technology lies not in the genius of its maker but in the embedding in societies' needs. Still, this does not mean that no novel technology will be accepted if it does not fit societies' needs exactly. Societal influences on novel technologies' design are often hidden and not the only factor that decides upon whether an innovation is successful.

Rather than creating society, technologies are created, accepted and embedded because of the needs of society, whether they be cultural, economic or of any other nature. This however, does not say anything about how innovation should be shaped, only about that they are shaped as such. To be able to intervene would demand knowledge of the societal factors involved, and manipulating these. The need for food, or energy as well as issues of fashion, culture etc. are then the key to steer the innovation process rather than internal knowledge of the technology in question. Often it appears that those factors considered to be irrelevant were decisive in retrospect on the success or failure of a novel technology. Still, technologies innovation and technology design cannot be regarded as merely a side-product of sociological phenomena. They have an internal logic as well which cannot be disregarded when looking at an innovation process.

To be able to steer between different deterministic frameworks that only bear relevance in an evaluative sense, one needs to accept the complexity of an innovation process. In the development and implementation of different biofuels, this was also acknowledged during both debates: rather than either going for yet another 'technological fix' for problems of sustainability, and rather than aiming for a 'societal' fix, one needs to take into account as many important factors as possible. This is only possible if one creates a platform where as many stakeholders as

[16] For a written account of the discussions, see www.parrhesia.info.

possible are offered the possibility to speak out. An important outcome of both debates therefore was the necessity for a multidisciplinary approach of innovation processes that integrates more than one perspective, be it economic, social, cultural, environmental or technological. This is the only way to define a goal-orientated rather than an evaluative perspective to technology innovation.

As was remarked during the debates: "*biofuels are an UPO, an unidentified political object: too complex an issue to approach from one mono-causal (technological) perspective, and politically dangerous ground to tread*".[17] In other words, any approach that attempts to reduce the technological developments with regard to biofuels to either a technology-driven innovation that steers society, or a society-driven need for sustainable products, is bound to lead to oversimplification Neither of these two perspectives is productive. We live in a world that increasingly needs energy, for electricity, transport etc. These needs cannot be reduced, but the engineer will not be able to present one technological fix such as biofuels as the "Holy Grail for sustainability" either. We have to look upon technology and society as reciprocally constructed. After recognizing that technology and society are mutually and reciprocally constructed, and after coming to understand that early techno-scientific developments are often quite malleable, many people might begin wondering about how a civilization could use that flexibility to negotiate and construct better than humanity has done up until now: "*How should technologies be constructed? Which 'relevant social groups' ought to be included in the process? Are there morally preferable ways for the creation of technological frames? How should interpretive flexibility come to closure? When and how should closure be re-opened?*" Also arising are many empirical issues concerning institutional arrangements conducive to fairer negotiations and wiser use of technical potentials."[18] There were also those who voiced the idea that one should not look upon the hidden drivers in the debate as negative drivers but to the fact that they are hidden as negative. In the debate on biofuels, the better informed participants were, the better they knew that complexity needs to be acknowledged rather than resolved: "*[…] the "informed public" debate abandons the traditional position of technological determinism. Science and technology appear as a social process that is influenced by different interests. As such, there is a demand for information that is more complete, which bears in mind both the conflicts as well as the diverse technological directions that are possible, and which is in agreement with what we call the democratic model of scientific-technological news.*"[19] With a complex issue such as biofuels, any form of reductionism tends to present nice, simple overviews of what should be done, but without them bearing upon reality. There is a multitude of drivers and stakeholders involved in the implementation of biofuels. That biofuels were brought to the attention of the audience as if there were only one driver has led to the current polarisation. To be able to assess the value of implementing biofuels, one needs to create a platform where the different stakeholders involved can articulate their views openly, this may aid in avoiding public distrust.

17 Ibid.

18 See Woodhouse (2005).

19 http://www.foe.co.uk/resource/reports/greasy_palms_impacts.pdf.

Conclusion

New technologies are developed not within isolation. They do not emerge from behind the closed doors of the laboratory. Research is influenced by the preferences and ideas of the researcher as well as by societal needs and preferences. It is not clear-cut that every involvement of the public increases the quality of the innovation process, nor that it increases society's level of acceptance of novel technologies. In the past few decades, public tendencies to science-pessimism and—scepticism caused a gap between public and science. It appears that the more conscious and knowledgeable the public is of novel technologies, the more they seem to focus on the risks associated with them. But because innovation in technology affects society, scientists and policy makers need to acknowledge public opinions as a necessary part of the development of sustainable technology.

One has to take into account societal, economic and technological determinants, without reverting to either of these as a 'true' base of the reality of innovation. Society and technology should be seen as co-evolving, but this co-evolution can be intervened into in a proactive fashion. Technological innovation does take place in a socio-cultural arena, since technological innovation is indeed influenced by its success or non-success in society, but it should not be reduced to sociological phenomena. To be able to do this, a study is needed on what values and interests play into the different positions held by different stakeholders, with regard to novel inventions in white biotechnology.

The real question should be how can we steer the co-evolution of science, technology and society in a responsible fashion. To this aim, more explicit information and communication on background values and interests are needed. This would lead to better understanding of each other's positions. In this sense, one needs to make use of polarisations in a debate. This facilitates making explicit implicit values and interests that influence the debate. This debate needs to be open-ended. In this way one can decrease the tendency for polarisation, increase the quality of the public debate and create an environment in which the decision making process in drawing up new policies can be developed faster and in a qualitatively more founded and justified fashion.

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